**US Army Corps
of Engineers**
Waterways Experiment
Station

Navigation Conditions at McAlpine Locks and Dam, Ohio River

Hydraulic Model Investigation

by Ronald T. Wooley

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Prepared for U.S. Army Engineer District, Louisville

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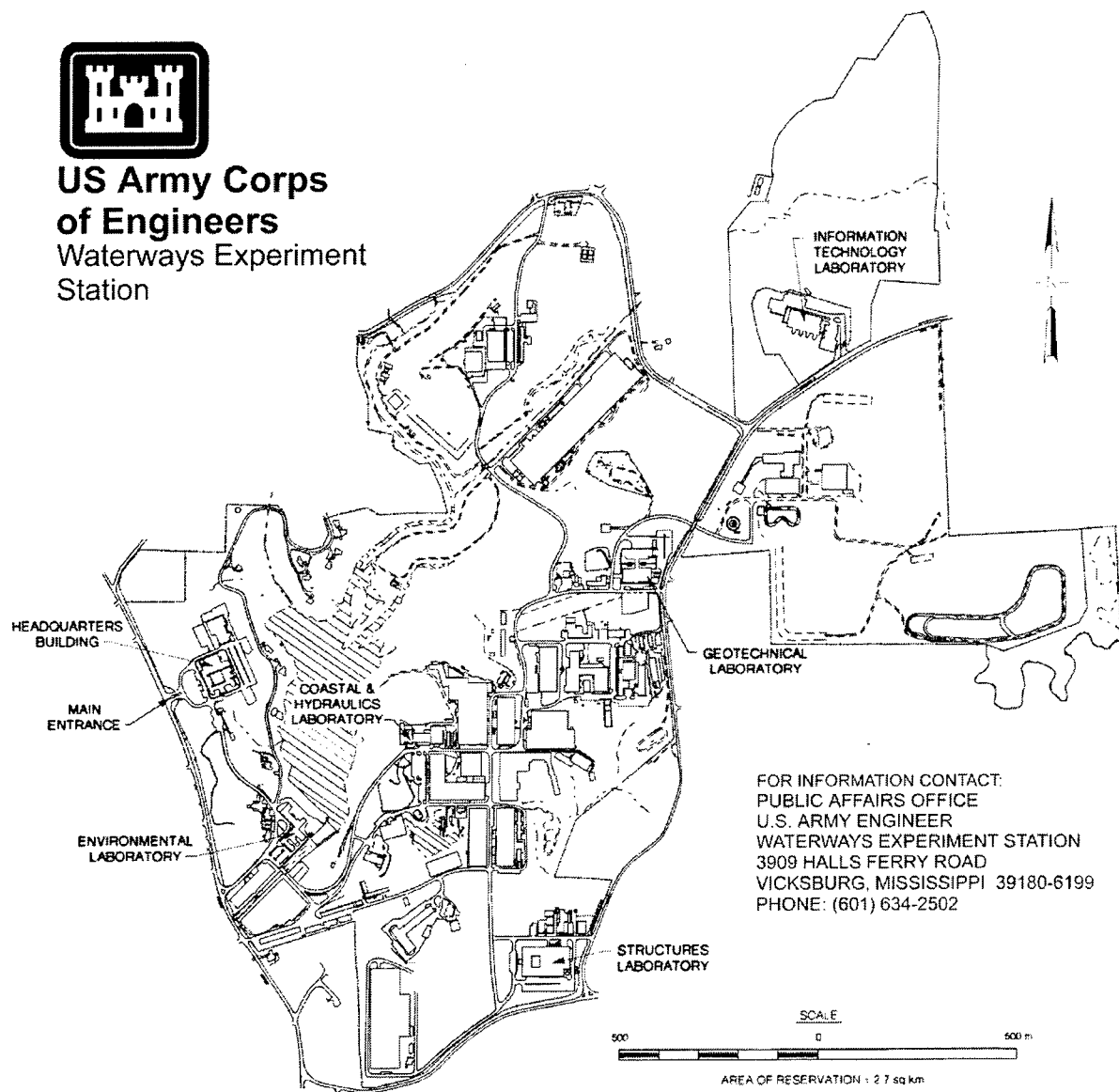> 3909 Halls Ferry Road
> Vicksburg, MS 39180-6199

Final report

**US Army Corps
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Waterways Experiment
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STRUCTURES
LABORATORY

SCALE

500   0   500 m

AREA OF RESERVATION : 2 7 sq km

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Preface

The model investigation reported herein was conducted for the U.S. Army Engineer District, Louisville (ORL), and was authorized by the Office, Directorate of Civil Works, Headquarters, U.S. Army Corps of Engineers, in an indorsement dated 1 August 1990 to the Division Engineer, U.S. Army Engineer Division, Ohio River. The study was conducted by the U.S. Army Engineer Waterways Experiment Station (WES) during the period August 1990 to March 1997.

During the course of the model study, representatives of ORL and other navigation interests visited WES many times to observe special model experiments and to discuss the results of those experiments. ORL was informed of the progress of the study by monthly progress reports and a special presentation at the conclusion of each experiment.

The first-line review of this report was conducted by Mr. T. J. Pokrefke, Chief, Modeling Systems Branch, Estuaries and Hydrosciences Division, Coastal and Hydraulics Laboratory (CHL). The principal investigator in immediate charge of the model study was Mr. R. T. Wooley, assisted by Mr. J. W. Sullivan and Ms. D. P. George, all of the Navigation Branch, Navigation and Harbors Division, CHL. This study was conducted under the direct supervision of Dr. L. L. Daggett (retired), Chief, Navigation Division, CHL, and under the general supervision of Mr. R. A. Sager, Assistant Director of CHL, and Dr. J. R. Houston, Director of CHL.

Director of WES during preparation and publication of this report was Dr. Robert W. Whalin. COL Robin R. Cababa, EN, was Commander.

Conversion Factors, Non-SI to SI Units of Measurements

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
feet	0.3048	meters
miles (U.S. statute)	1.609344	kilometers

1 Introduction

Location and Description of Prototype

McAlpine Locks and Dam are on the Ohio River at the northwestern end of Louisville, KY (Figure 1), 606.8 miles[1] below Pittsburgh, PA. The structures, including the dam, canal, and locks, extend from mile 604.4 to mile 607.4. The upper pool of the dam extends approximately 75 miles upstream to Markland Locks and Dam near Warsaw, KY.

Precipitation over the Ohio River basin above Louisville is generally well distributed throughout the year, but flood-producing rainfall occurs generally in the winter and early spring. Flood stage of el 431.0[2] at Louisville (upstream of the dam) is reached with an average frequency of once in 15 years. The highest flood of record reached a peak elevation of 460.1 at the dam in January 1937 and had a maximum discharge of 1,110,000 cfs. The second highest flood of record occurred in March 1945 with a peak elevation of 450.1 and a maximum discharge of 843,000 cfs. Most of the areas next to the project, including Louisville and New Albany, Clarksville, and Jeffersonville, IN, are protected from flooding by levees and floodwalls.

History of Navigation Improvements on the Ohio River

In its natural state, the Ohio River was obstructed throughout its length by snags, rocks, gravel, and sandbars, which rendered navigation extremely difficult and hazardous. Controlling depths during low water were 1 to 2 ft from Pittsburgh, PA, to the river mouth at Cairo, IL. From about 1824 to 1910, funds were appropriated periodically for navigation improvements, which consisted principally of removal of snags and wreckage from the channel and construction of stone training dikes to contract the channel and increase the scouring action of the river. During this period, the principal Ohio River traffic consisted of downbound coal tows assembled in the Pittsburgh harbor area and moved downstream during higher river stages that provided sufficient depth.

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[1] A table of factors for converting non-SI units of measurement to SI units is found on page vi.
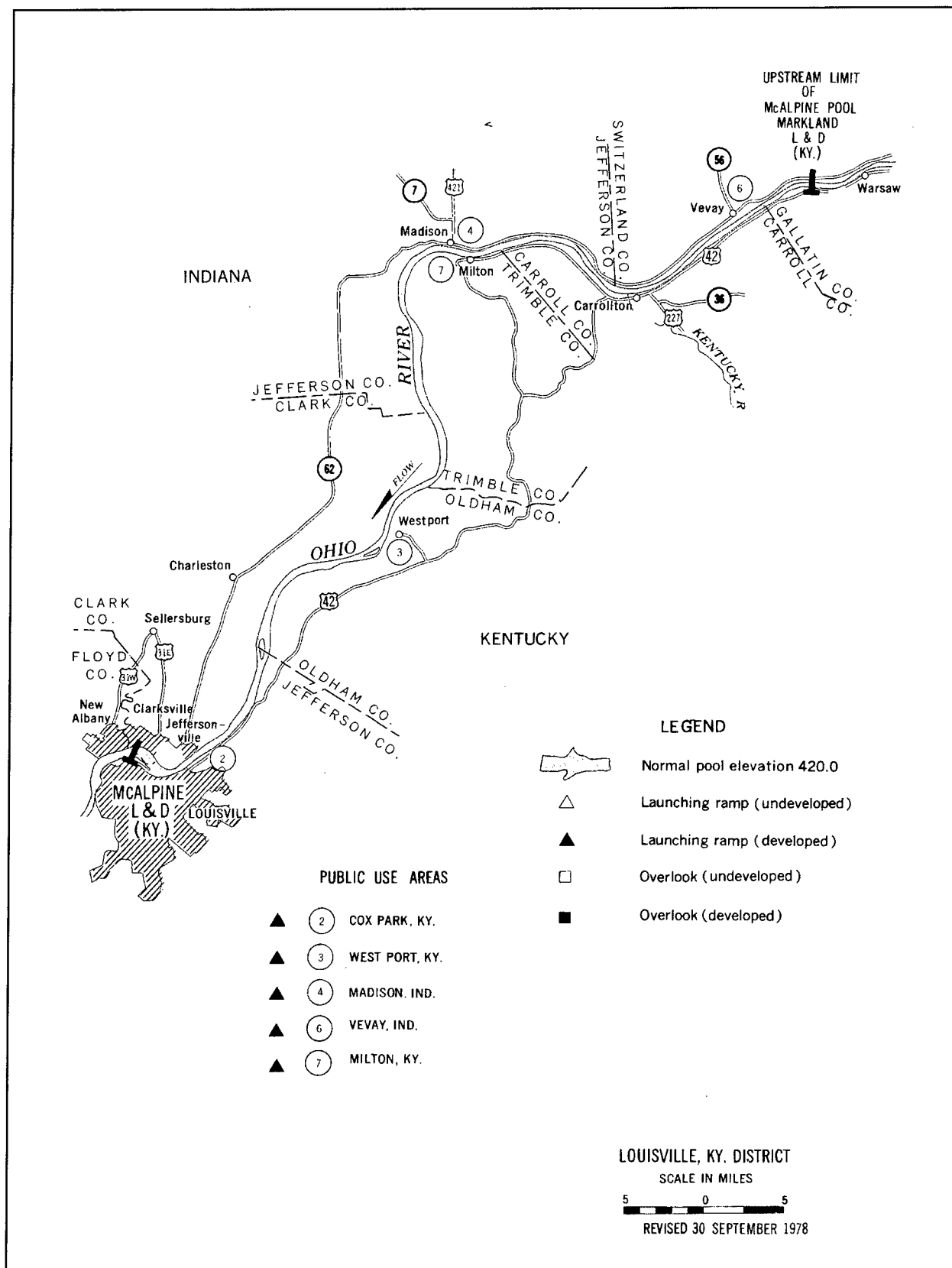[2] All elevations (el) cited herein are in feet referred to the Ohio River Datum.

Figure 1. Location map

Initially, coal transport interests opposed the construction of locks and dams. They wanted to use regulatory works to maintain required depths and thus keep a free passage under open-river conditions. However, this was not possible without constricted channels and excessive velocities, which would be hazardous to downstream navigation and would render upstream navigation impossible. Because of these conditions, the need for locks and dams was finally recognized. To eliminate obstacles to downstream traffic, a movable dam was adopted that could be lowered to the bed of the river, thus permitting free passage of downbound tows when natural flows provided sufficient depths. Since loaded upbound traffic was an extremely small part of the total traffic at that time and no material change was foreseen, little consideration was given to upbound traffic.

The River and Harbor Act of 25 June 1910 provided for the construction of 54 locks and dams. During construction, certain substitutions and elimination of structures were made in the plans so that the project consisted of 50 locks and dams when completed in 1929. After its completion, the project was further modified so that the system was composed of 46 locks and dams; of these, 42 were movable, 1 was fixed, and 3 were nonnavigable, gate-controlled structures. The dams were designed to maintain a minimum slack-water channel of 9 ft. Pool lifts ranged from 5.6 to 37.0 ft. All dams had at least one 110- by 600-ft lock, and five had an auxiliary lock; four of the auxiliary locks were 56 by 360 ft.

The original navigation projects, as modified in the 1930's, comprised 46 dam-lock structures and the Louisville and Portland Canal (L&P Canal) at Louisville. A modernization program, initiated in 1954, provides for continuing the 9-ft project depth by the progressive replacement of existing structures by 19 high-lift structures. The modern units consist of nonnavigable gated dams, a main lock (110 by 1,200 ft), and a second lock (110 by 600 ft), except at Smithland, which has two 1,200-ft locks. McAlpine has a third lock chamber (56 by 360 ft), which is not operable.

Conditions of Existing Structures

Reconstruction of Locks and Dam 41 (McAlpine Locks and Dam) was part of the general plan of improvement of navigation on the Ohio River. No change would be made to the existing upper pool elevation of 420.0, which would provide navigable depths to Markland Locks and Dam. Modernization of McAlpine Locks and Dam was begun in 1954, and by 1962, a new 110- by 1,200-ft lock was in operation. The modernization plan also included reconstruction and widening of the upper lock entrance canal, installation of a surge basin in this canal, and provision for a nonnavigable, gate-controlled dam in place of the Boulé dam and Chanoine wicket dam. The new dam has since been completed and consists of nine tainter gates, four near the powerhouse and five just above the Pennsylvania Railroad bridge, and a fixed weir with a crest at el 422.0 at the four downstream gates, incrementally raised to a crest elevation of 423.0 at the five upstream gates.

Present Development Plan

The McAlpine Navigation Feasibility Report for the project was completed and forwarded to the U.S. Army Engineer Division, Ohio River, in 1989. The provisional recommended plan consists of constructing an additional 110- by 1,200-ft lock in place of the existing auxiliary chamber. This would result in two locks 110 ft wide by 1,200 ft long. The new lock would be parallel to the existing 1,200-ft lock, with the upper gates in approximately the same location as the existing lock upper gate. A guide wall would extend upstream 1,275 ft beyond the upper miter gate monolith and tie into the existing canal wall. A south guide wall would extend 1,200 ft beyond the lower miter gate monolith.

Need for and Purpose of Model Study

The general design of the new 1,200-ft-long lock was complicated by its proximity to the existing 1,200-ft lock, its placement at the downstream end of a long approach canal, and the restricted area downstream of the lock available for lock discharge laterals. Because of the many design factors that had to be considered, a physical model was considered necessary to evaluate navigation conditions in both the upper and lower approaches to the locks. Surges, created by filling the existing 1,200-ft lock, have the potential for causing adverse navigation conditions in the L&P Canal. Filling two 1,200-ft locks from the canal could create a more serious problem in the future. The comprehensive model study was necessary to (a) evaluate the effect of surges on tows near the locks, (b) develop guidance for future project operations to reduce or eliminate problems associated with lock filling, (c) evaluate bendway widening near the locks, (d) evaluate necessary clearances between tows and resolve other questions relating to multiple tow movements in the canal, and (e) investigate the impact of lock emptying on navigation in the lower approaches to the locks.

2 The Model

Description

The model is a 1:80-scale fixed-bed model reproducing the L&P Canal, the existing locks, a limited section of the Ohio River immediately upstream of the canal, that part of the river channel between Shippingport Island and the fixed crest weir connecting the upper and lower spillways, and the lower approach to the locks (Figure 2). Upstream of the lower spillway, the right descending model limits followed the alignment of the fixed-crest weir from the upper gated spillway to the lower gated spillway. However, as the model would not be reproducing any riverflows that would create flow over the fixed-crest weir, the crest elevation of the weir was not reproduced in the model. The model was constructed of a sand-cement mortar molded to sheet metal templates except for part of the main river channel between the Conrail Railroad bridge and the hydropower plant, which was molded in sand. The L&P Canal and the lower lock approach were molded to a 1991 hydrographic survey. The remaining portion of the model was molded to recent hydrographic and topographic surveys. The locks, powerhouse, gated spillway, and bridges were constructed of sheet metal.

Scale Relations

The model was built to an undistorted scale of 1:80, model to prototype, to reproduce accurately velocities, crosscurrents, and eddies affecting navigation. Other scale ratios resulting from the linear scale ratio are as follows:

Characteristic	Dimension[1]	Scale Relation Model:Prototype
Area	$A = L_r^2$	1:6,400
Velocity	$V = L_r^{1/2}$	1:8.94
Time	$T = L_r^{1/2}$	1:8.94
Discharge	$D = L_r^{5/2}$	1:57,243
Roughness (Manning's n)	Manning's $n = L_r^{1/6}$	1:2.08
[1] Dimensions are in terms of length L.		

Figure 2. Model limits and gauge locations
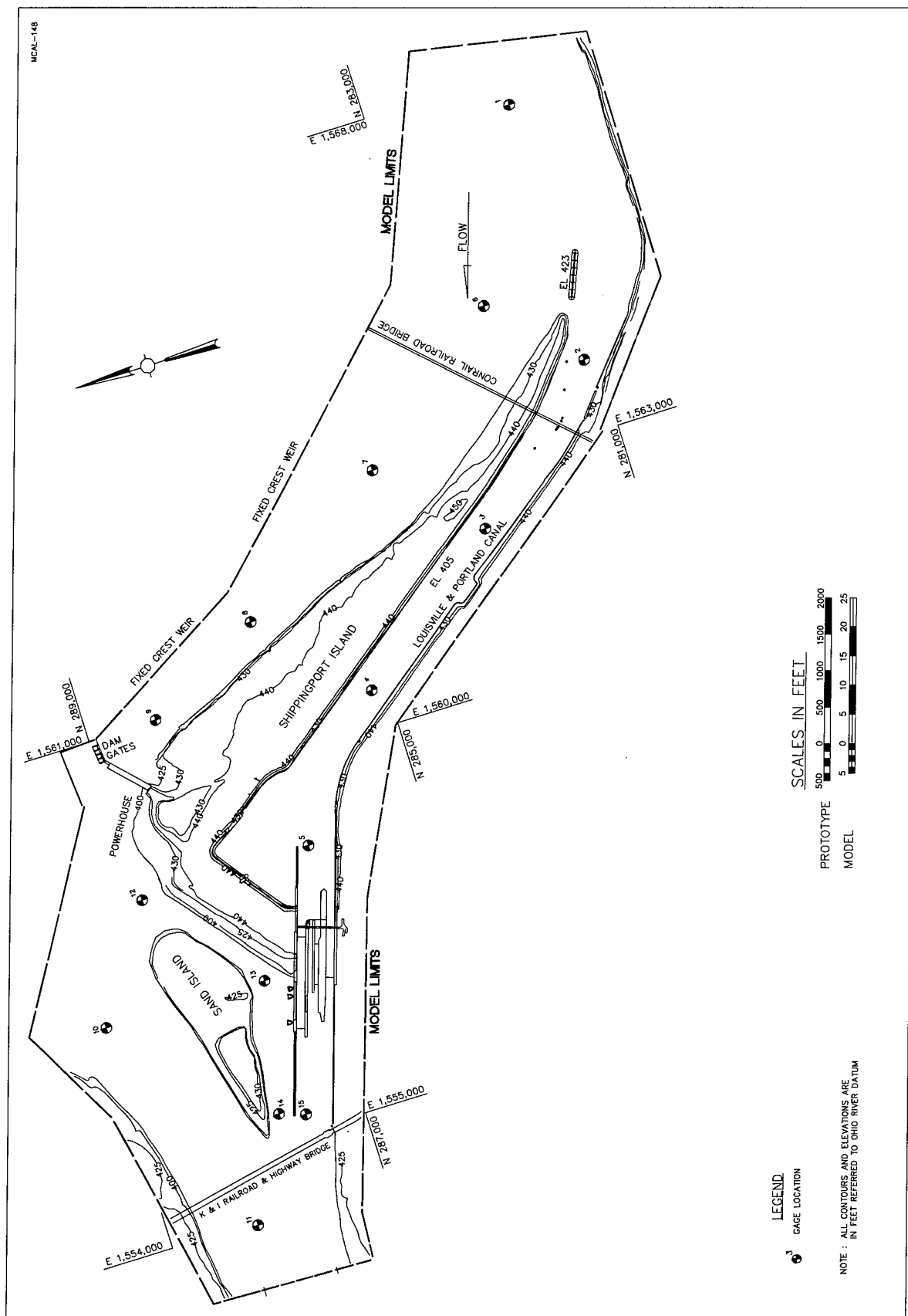
Measurements of discharges, water-surface elevations, and current velocities can be transferred quantitatively from model to prototype equivalents by these relations.

Appurtenances

Water was supplied to the model by a 10-cfs pump operating in a circulating system. The discharge was controlled and measured at the upper end by a valve and venturi meter. Water-surface elevations were measured by 15 piezometer gauges in the model channel connected to a centrally located gauge pit (Figure 2). Surges in water-surface elevations were measured upstream of the locks with five sonic water-level gauges placed along the canal and in the main river channel (Figure 3). Surges were measured downstream of the locks with four sonic water-level gauges in the navigation channel downstream of the locks (Figure 4). Surges in current velocities were measured with a miniature velocity meter at selected stations. A hinged tailgate was provided at the lower end of the model to control the tailwater elevations downstream of the dam, and slide-type gates in the spillway were used to control the upper pool elevation. The flow through the spillway was distributed across the lower channel by a baffling system to simulate the current patterns that could be expected with normal spillway flow.

Model Adjustment

A limited amount of prototype current directions and velocity measurements was available; however, the data were taken with river discharges higher than those used for model experiments. Therefore, current patterns at the entrance to the model and in the river channel downstream of the dam were adjusted to reflect normal patterns that occur with the channel shape reproduced. Prototype measurements of changes in water-surface elevations and current velocities during lock filling were available for five locations and one location, respectively, as shown in Plates 1 and 2. The surface of the model was constructed of brushed cement mortar to provide roughness (Manning's n) of about 0.0135, which corresponds to a roughness in the prototype of about 0.028. With the model simulating conditions existing in the prototype at the time of the study, water-surface elevations and current velocities were measured in the model during filling of the existing 1,200-ft lock and compared with prototype data supplied by the U.S. Army Engineer District, Louisville. Data in Plates 1 and 2 show the model reproduced the prototype measurement with a reasonable degree of accuracy and was adequate for the model study.
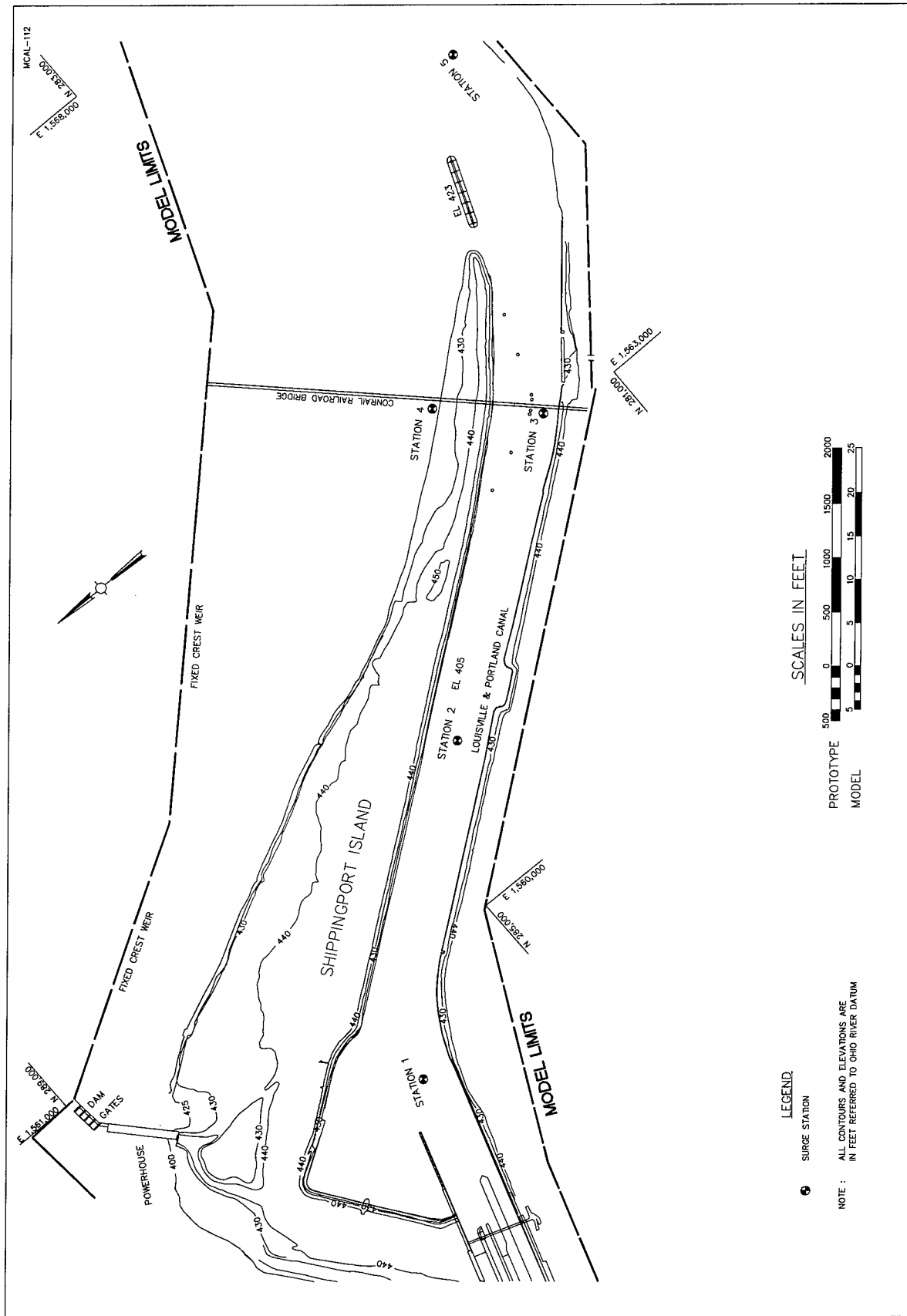
Figure 3. Location map, upper pool surge stations
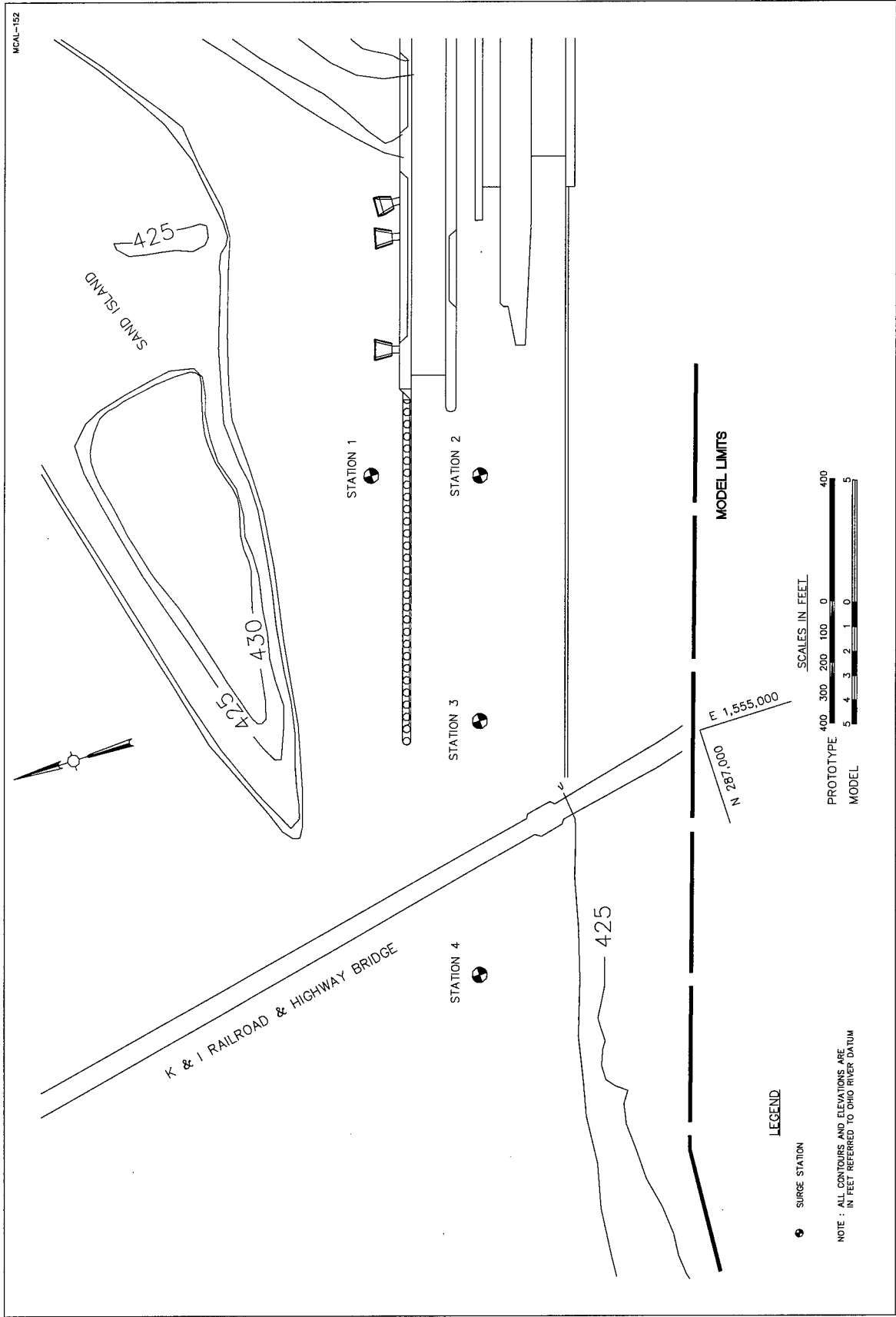
Figure 4. Location map, lower pool surge stations

3 Experiments and Results

Tests were concerned primarily with the study of current patterns, measurements of velocities and water-surface elevations, and the effects of currents on the movement of the model tow, described in the next section, in the lock approaches during lock operation.

Experiment Procedures

The largest surge in water-surface elevations and velocity of currents due to lock filling or emptying occurs when the head differential between the upper and lower pools is the greatest. Therefore, in collaboration with the Louisville District, a discharge with a large head differential between upper and lower pools was selected for all experiments. Prototype measurements were collected with a total river discharge of 12,000 cfs with a head differential of about 36.5 ft; therefore, that discharge was selected for most experiments.

The riverflows were reproduced by introducing the proper discharge at the upstream end of the model and manipulating the tailgate until the required tailwater elevation was obtained. The upper pool was maintained by adjusting the gates of the dam, maintaining a uniform opening for all gates. With the 12,000-cfs riverflow, all flow was passed through the lower spillway except during lock filling.

Velocities and current directions were measured in the model by tracking the movement of lighted floats with respect to ranges established for that purpose. Confetti and dye were also used to show current patterns in eddies. Multiple-exposure photographs recorded the current patterns with various conditions, and a miniature current meter measured spot velocities at various stations during lock operation. A radio-controlled model tow and towboat were used to study and show the effects of currents on navigation. The model tow was equipped with twin screws, Kort nozzles, and driving and flanking rudders, and was powered by a small electric motor operating from batteries in the tow. The tow in the study represented fifteen 195-ft-long by 35-ft-wide standard barges with a 120-ft-long pusher. This provided an overall size tow of 1,095 ft long by 105 ft wide, loaded to a draft of 9 ft. The towboat operated in forward or reverse at various speeds and with variable rudder settings. It was calibrated to the speed of a comparable-size prototype towboat moving in slack water. To maintain

rudder control but not overpower the currents, the tow was operated 1 to 2 miles per hour above the speed of the currents. The paths of tows were determined by tracking the path of the light mounted on the tow with the video-tracking system mounted overhead of the model. Velocities of the tows were measured with a desktop computer equipped to calculate velocity based on the time required for the tow to pass over a measured distance. This method provided detailed information of the tow movement during the experiments.

The rate of lock filling and emptying was recorded by computer and compared with the computed prototype curves. Each condition was subjected to a minimum of three lock filling or emptying experiments; and if they were not close to the computed curves, the experiment was repeated to obtain three experiments with comparable curves. With most conditions, only three experiments were necessary. In the interest of clarity, only one set of data is shown on the plates.

Base Experiments (Existing Conditions)

Description

Base experiments were conducted with the model reproducing conditions existing in the prototype at the time of the model study. These experiments provided information and data that could be used to evaluate the effects of proposed modifications on water-surface elevations, current direction and velocities, and navigation conditions. The following principal features were reproduced or simulated in the model (Figures 5 and 6):

a. Navigation locks located along the left bank at the downstream end of a 1.75-mile-long canal. The main lock had clear chamber dimensions of 110 ft wide by 1,200 ft long (Figure 6). The two auxiliary locks, which were out of service, were between the main lock and left bank. The canal was 500 ft wide with a bottom elevation of 405.0 (Figure 2).

b. A powerhouse located along the left bank adjacent to the downstream end of Shippingport Island and a four-gated spillway section located adjacent to the powerhouse (Figure 2).

c. The Conrail Railroad Bridge that crosses the L&P Canal immediately downstream of the entrance of the canal. A lift span provides vertical clearance for navigation through the bridge. The left descending pier of the navigation span is landward of the canal and the right pier is protected by guard cells upstream and downstream of the pier. The horizontal clearance between the left bank of the canal and the guard cells is 241.5 ft (Figure 7).

d. The Kansas and Illinois Railroad bridge that crosses the lower approach of the locks immediately downstream of the locks (Figure 2). The left pier of the navigation span was landward of the landside guide wall of the new

Figure 5. Conditions existing at time of study
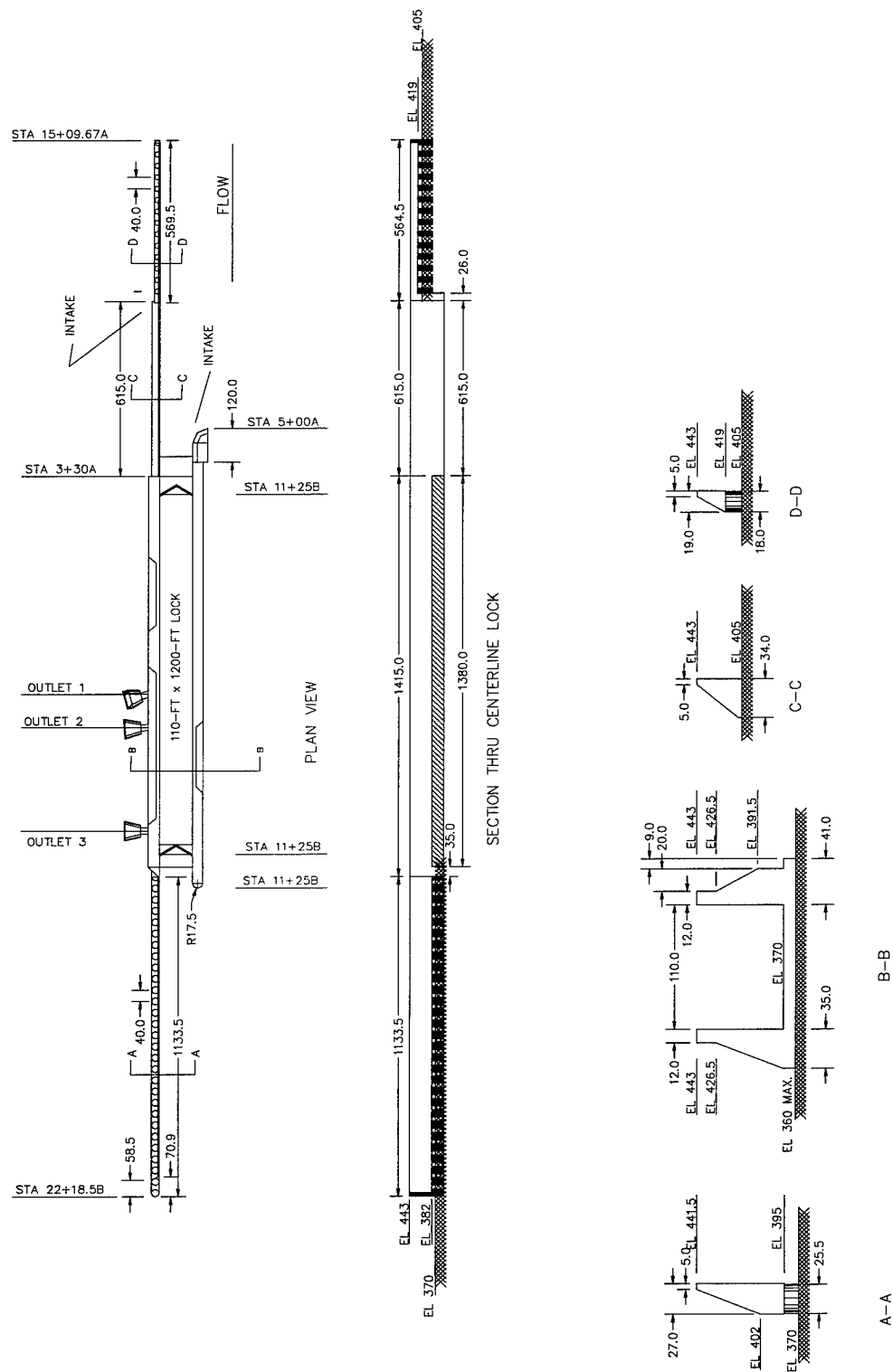
Figure 6.   Existing 1,200-ft lock plan and sections

MCAL-154

SHIPPINGPORT ISLAND

EL 423

430

440

NAVIGATION SPAN
241.5-FT HORIZONTAL CLEARANCE

430

440

E 1,563,000

N 281,000
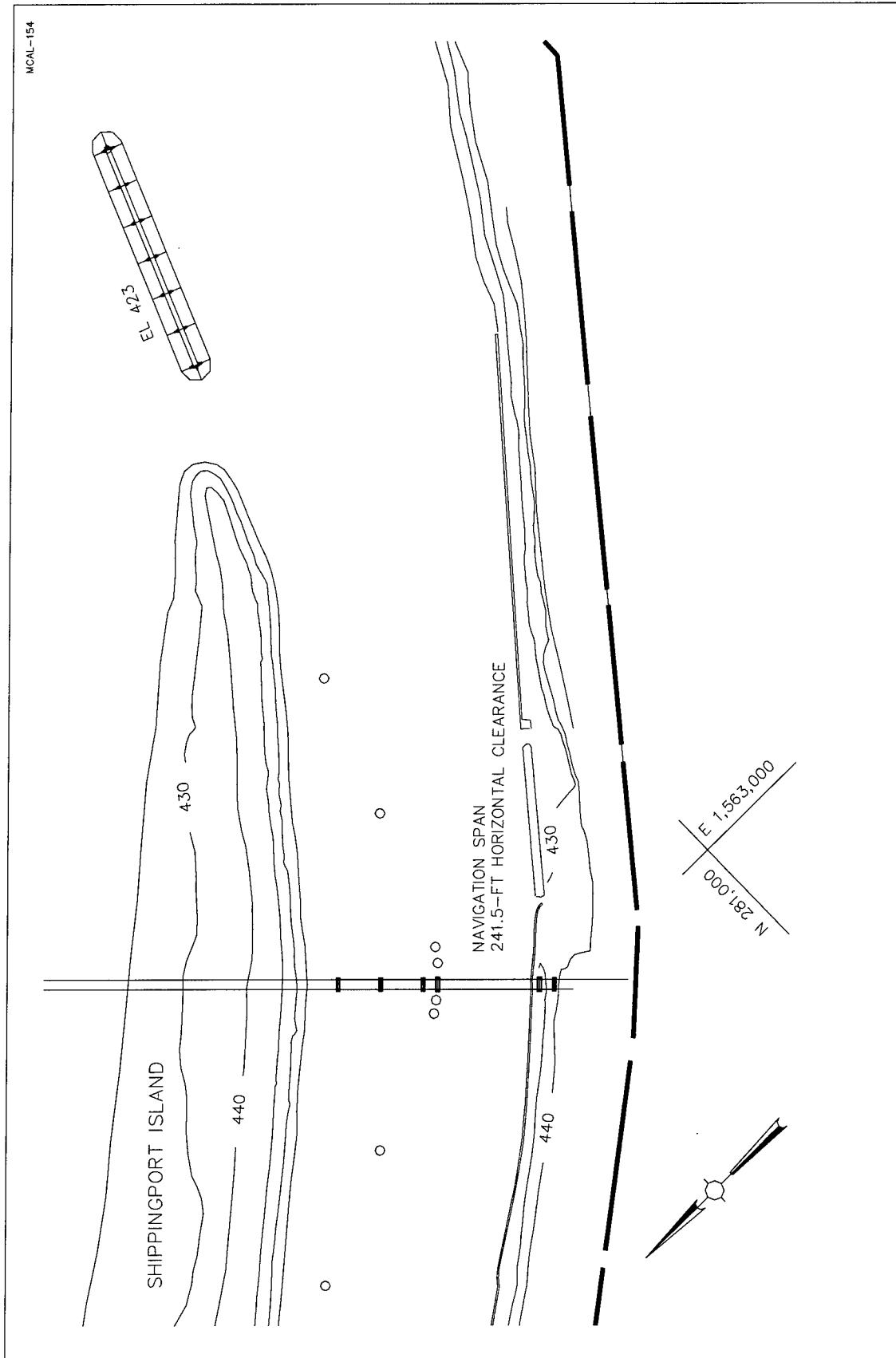
Figure 7. Conrail Railroad bridge navigation span

lock and the right pier was riverward of the riverside guard wall of the existing 1,200-ft lock. Therefore, the piers did not interfere with tows entering and leaving the lower lock approach.

Results

Lock filling experiments. Experiments were conducted to evaluate the effects of lock filling on the magnitude of surges in the L&P Canal. Before experiments were undertaken, the model lock filling system was adjusted until the rate of lock filling was close to the curve developed from data furnished by the Louisville District for the existing 1,200-ft lock. A comparison of model and computed prototype filling curves shows close agreement (Plate 3). However, near the end of the filling cycle, the rate of filling was slower in the model. The model simulated a 10-min filling time.

Surges in water-surface elevation due to lock filling are shown in Plate 1. These data show that the model result compares favorably with prototype measurements. The initial drawdown of the water surface due to the lock filling was in close agreement with the field data, in both time of occurrence and the amount of drawdown. The field and model data show that a repetitive surge is created in the upper pool by lock filling. The largest change in water-surface elevation occurs at station 1, which is close to the lock, and diminishes as the stations progress upstream toward the main river channel. Secondary surges occur as the filling cycle is completed and withdrawal of water from the canal stops. These secondary surges may continue for several hours with diminishing heights.

Depending on the station observed, the initial surge due to lock filling occurred about 8 to 20 min after the start of filling the lock and decreased the water-surface elevation about 1.1 ft at stations 1 and 2, 0.7 ft at station 3, and 0.4 ft at stations 4 and 5 (Plate 1). A secondary surge occurred about 20 to 40 min after the start of filling, depending on the station observed, and increased the water-surface elevation over the flat pool about 1.0 ft at station 1, 0.5 ft at station 2, 0.2 ft at station 3, and less than 0.1 ft at stations 4 and 5. Data in Plate 2 show the velocities of the currents generated by lock filling varied from a positive 2.5 to a negative 1.1 fps at station 3, which is in the most restricted section of the canal. A secondary surge occurred about 50 min after the start of lock filling, which varied from a positive 1.3 to a negative 1.0 fps. The velocities of the currents were lower at stations 1 and 2 due to the cross section of the canal being larger in these areas.

Lock emptying experiments. Experiments were conducted to evaluate the effects lock emptying would have on navigation and the magnitude of surges in the lower approach of the locks. Before experiments were conducted, the model lock emptying systems were adjusted until the rate of lock emptying was close to the curve developed from data furnished by the Louisville District for the existing 1,200-ft lock. Comparison of model and computed prototype emptying curves shows close agreement (Plate 4). However, near the end of the emptying cycle, the rate of emptying was slower in the model. During the experiments,
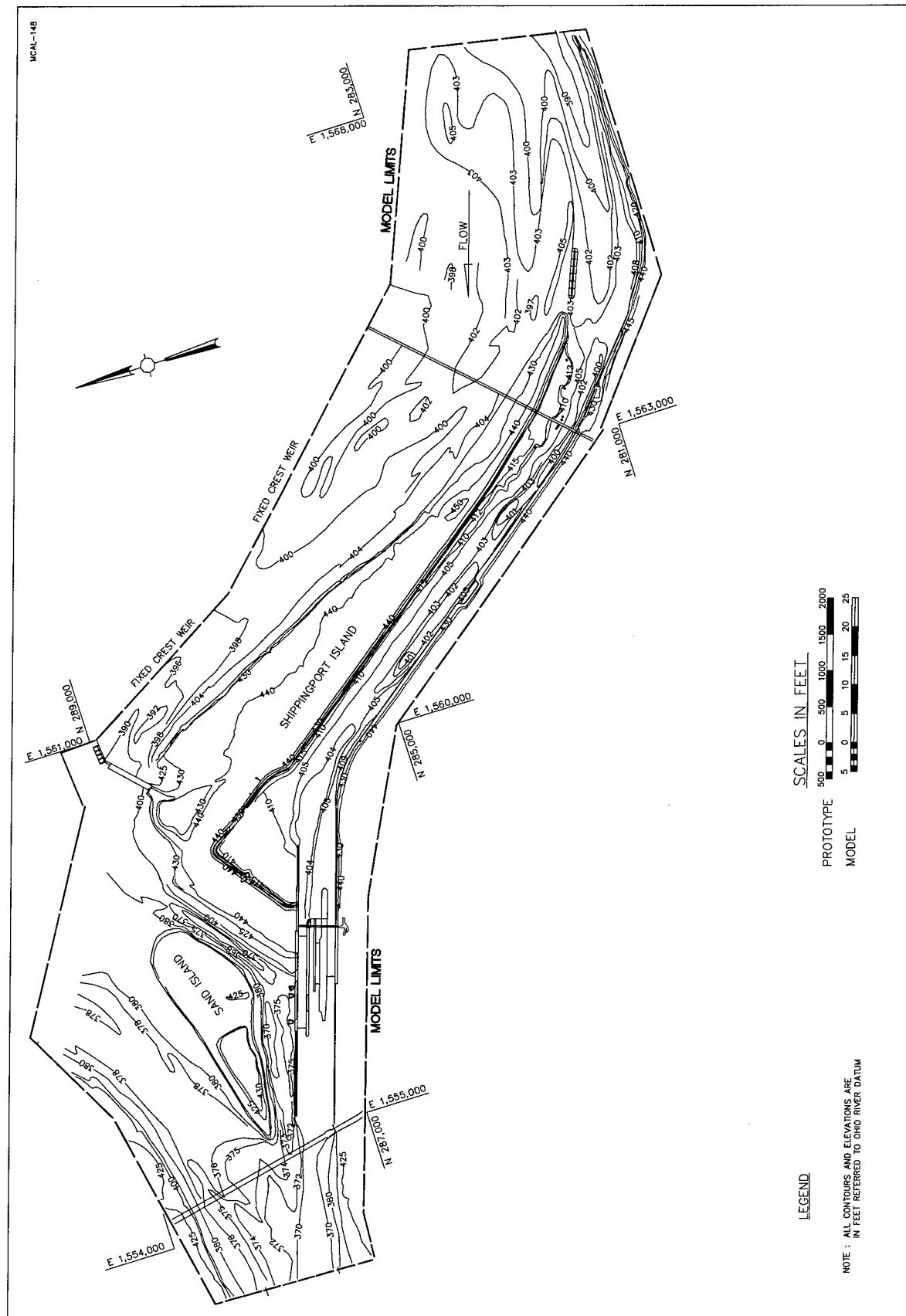
each emptying cycle was recorded by computer and compared with the computed prototype curve. Each condition was subjected to three lock emptying cycles, and when they did not closely agree with the computed curve, the experiment was repeated until three cycles with comparable curves were recorded. In the interest of clarity, only one cycle is shown in the plates. The model simulated a 10-min emptying time. It should be noted that the existing 1,200-ft lock discharges into the channel between the lock and Sand Island with the lower lock approach being protected from the flow by a 1,200-ft-long guard wall.

Surges in water-surface elevation due to lock emptying are shown in Plate 5. These data show that the water-surface elevation in the lower lock approach (stations 2 and 3) (Figure 4) changed less than 0.5 ft due to lock emptying. A surge in water-surface elevation of about 0.7 ft was recorded at station 1, which was in the channel between the lock and Sand Island. Secondary surges were minor at all stations.

Surges in velocity of currents due to lock emptying are shown in Plate 6. These data show surges in velocity of about 2.8 fps at station 1, 0.6 fps at stations 2 and 3, and 1.4 fps at station 4. Secondary surges were minor.

Plan A Experiments

Description

Plan A was the same as Existing Conditions except a second 110- by 1,200-ft lock was added to the left of and parallel to the existing 110- by 1,200-ft lock. The following were principal features of the new 1,200-ft lock (Figure 8):

a. A 110- by 1,200-ft lock was constructed in the place of the existing auxiliary chamber. The new lock was parallel to the existing 1,200-ft lock with the center line of the locks separated 335.5 ft. The upper gate pintle of the new 1,200-ft lock was aligned with the upper gate of the existing 1,200-ft lock. The design of the new lock was a mirror image of the existing lock. However, the upstream guide wall of the new lock was different from the existing lock.

b. The new lock had a 1,179.67-ft-long guide wall extending upstream from the upstream end of its south wall. The downstream 435.0 ft of the wall contained filling ports for the south lock wall. The remaining upstream 744.67 ft of guide wall was constructed on nineteen 18-ft-diameter cells placed on 40-ft centers. This design provided ports for flow to move through the wall. The tops of the ports were at el 419.0.

c. A 1,133.5-ft-long guide wall extended downstream from the downstream end of the south lock wall. The guide wall consisted of a solid concrete cap founded on twenty-eight 25.5-ft-diameter cells placed on 40-ft centers. The tops of the ports were at el 382.0.
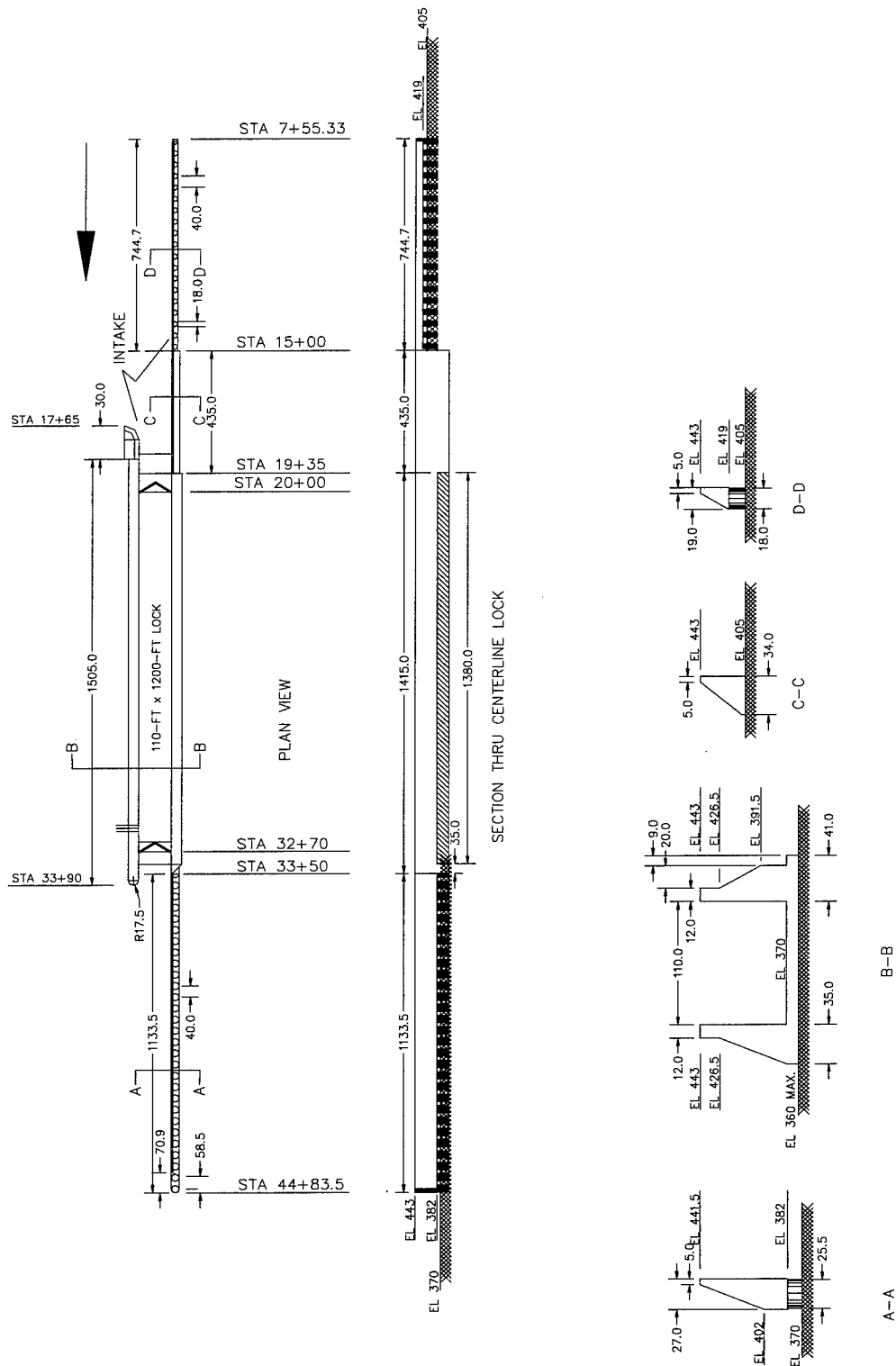
Figure 8. Plan A, plan and section, new 1,200-ft lock

d. The lock filling system consisted of the intake ports in the south guide wall (Figures 9 and 10) and intake ports in the curved part of the upstream end of the north lock wall (Figures 9 and 11).

e. The new lock had a lock emptying system that provided a diffuser in the lower lock approach immediately downstream of the lower miter gate to carry one-half of the flow from lock emptying. The remaining one-half of the flow was routed through a culvert extending from the north wall of the new 1,200-ft lock. The culvert crossed under the existing 1,200-ft lock and discharged through an existing discharge bucket into the back channel between the existing 1,200-ft lock and Sand Island (Figure 12).

Results of lock filling experiments with Plan A conditions

Experiments were conducted to record surges in water-surface elevation and current velocities. Surges were recorded during filling of each lock and during filling of both locks with 0-, 10-, 20-, and 30-min delay between the start of filling of the second lock. These data are shown in Plates 7-16. The experiments were conducted with a total river discharge of 12,000 cfs. However, a series of experiments was conducted with a total river discharge of 0 cfs to evaluate the sensitivity of the surges to total riverflow. These experiments showed total riverflow had some influence at stations 4 and 5, which were located in the main river channel (Figure 3), but very little influence on the surges in the L&P Canal.

Existing lock filling. Data presented in Plates 7 and 8 show that surges in water-surface elevation and current velocity created by filling the existing lock were generally the same as with existing conditions. Depending on the station observed, the initial surge due to lock filling occurred about 8 to 20 min after the start of filling the lock. This initial surge decreased the water-surface elevation about 1.1 ft at stations 1 and 2, 0.8 ft at station 3, and 0.3 ft at stations 4 and 5 (Plate 7). A secondary surge, which occurred about 20 to 40 minutes after the start of filling, increased the water-surface elevation over flat pool about 0.9 ft at station 1, 0.4 ft at station 2, 0.2 ft at station 3, and less than 0.1 ft at stations 4 and 5. Data presented in Plate 8 show that the velocities of the currents generated by lock filling varied from a positive 2.4 to a negative 1.3 fps at station 3, which is located in the most restricted section of the canal. A secondary surge occurred about 50 min after the start of lock filling that varied from positive 1.5 to negative 1.3 fps. The velocities of the currents were less at stations 1 and 2 due to the cross section of the canal being larger in these areas.

Both locks filling simultaneously. Filling both 1,200-ft locks simultaneously lowered the water-surface elevation about 2.1 ft at stations 1 and 2, 1.5 ft at station 3, and 0.6 ft at stations 4 and 5 (Plate 9). Depending on the station observed, a return surge occurred about 20 to 40 min after the start of lock filling. This surge raised the water-surface elevation about 1.2 ft over flat pool at stations 1 and 2, 0.3 ft at station 3, and less than 0.1 ft at stations 4 and 5. Some surging in water-surface elevation was still occurring at all stations approximately 140 min after the start of lock filling, with a change of 0.7 ft at station 1

Figure 9.   Plan A, intake port, south guide wall

LOCK FACE

FLOW

STA 16+63
CL PORT 8

R1.5

R1.5

R3.0

R1.9

4.0

5.0

7.3.5

2.5

3.3

10.7

13.3   10.6   10.6   10.6   10.6   10.6   10.6

95.0

18.4

PLAN VIEW

9.6

1.5   6.6

18.0

21.0

EL 381

EL 378

TYPICAL PORT
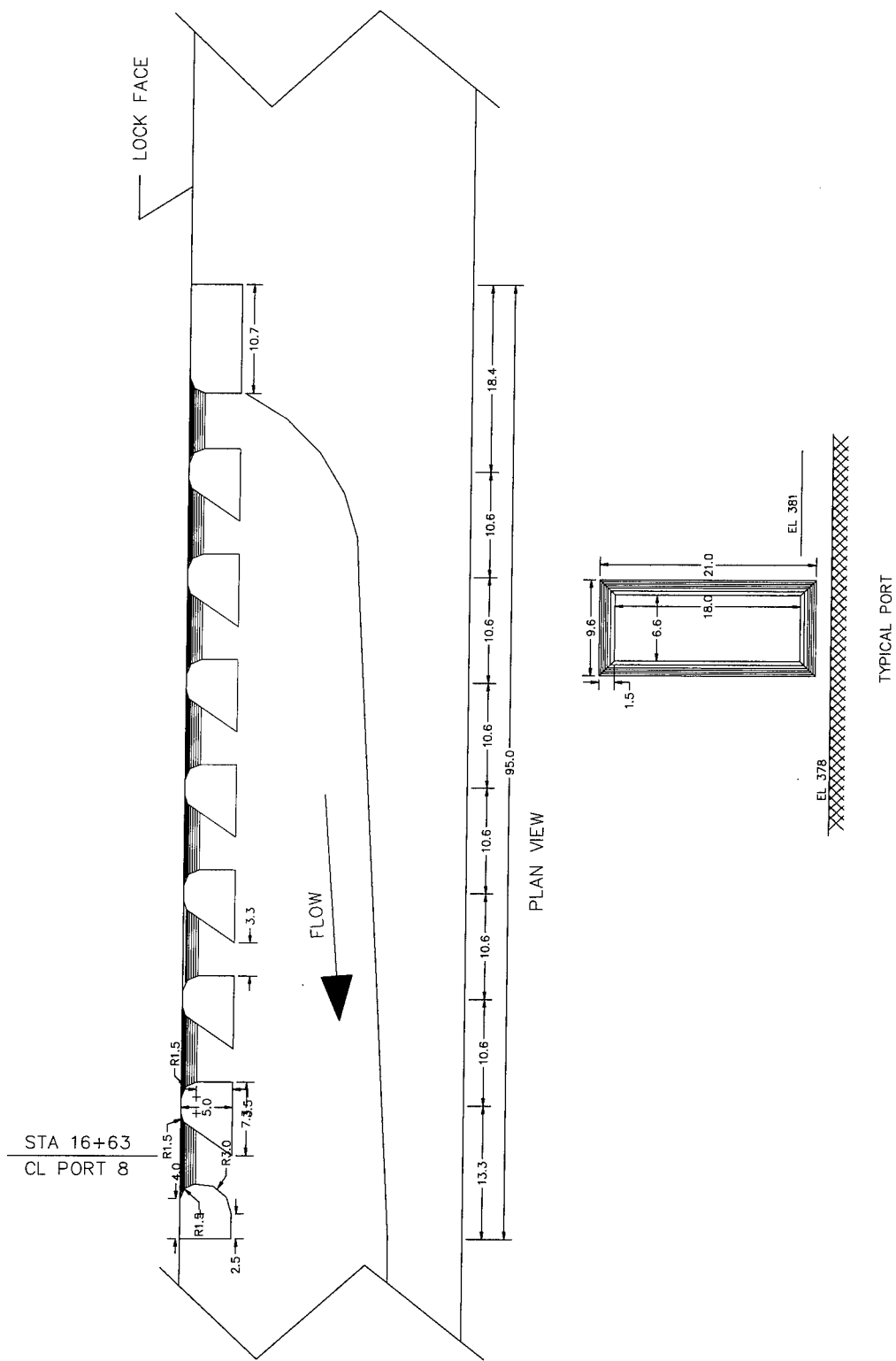
Figure 10.   Plan A, plan and elevation of south wall intake ports

Figure 11. Plan A, plan and section of north wall intake ports
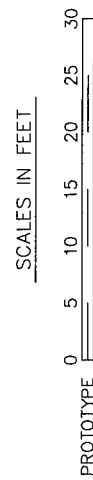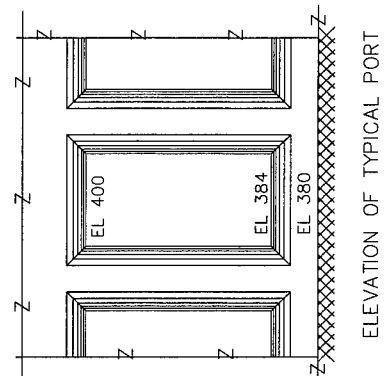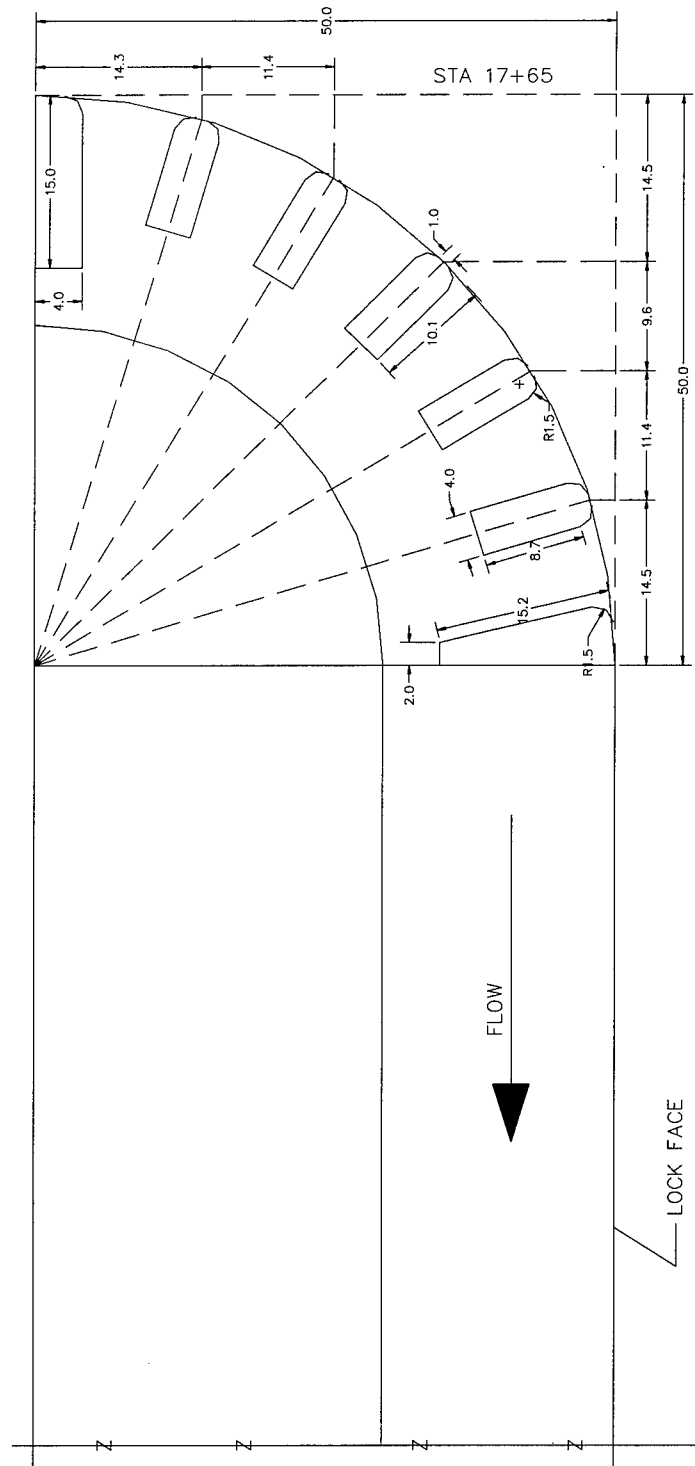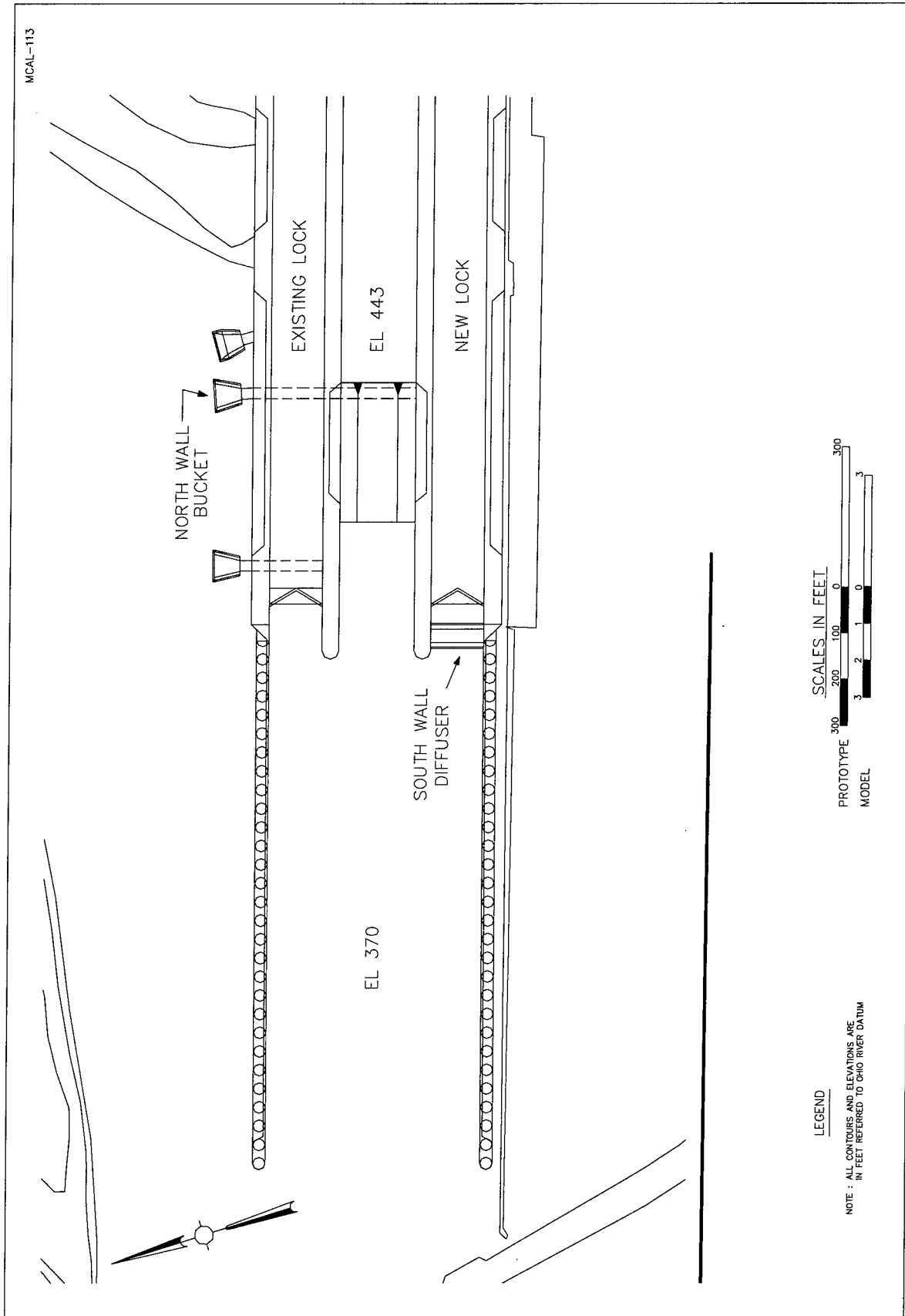
Figure 12.   Plan A, Scheme 1, emptying system

being the largest. Data presented in Plate 10 show that the velocities of the currents generated by filling both locks simultaneously varied from a positive 3.9 to a negative 2.2 fps at station 3. Approximately 130 min after the start of lock filling, the velocity of the currents was still fluctuating at station 3 from a positive 0.5 to a negative 0.5 fps.

Both locks filling, second lock delayed 10 min. When the start times of filling the locks were separated by 10 min, the magnitudes of surges in water surface and velocities were reduced considerably compared with simultaneous filling of the locks (Plates 11 and 12). The maximum surge in water-surface elevation occurred at station 2. Filling the locks lowered the water-surface elevation about 0.4 ft at station 1, 1.0 ft at station 2, 1.1 ft at station 3, and 0.6 ft at stations 4 and 5 (Plate 11). The interaction between the filling of the first lock and the second lock disrupted the wave pattern at station 1, resulting in short-period waves with a magnitude of about 0.5 ft. Depending on the station observed, a return surge occurred about 30 to 50 min after the first lock began filling. This surge raised the water-surface elevation about 0.8 ft over flat pool at station 2, 0.3 ft at station 3, and less than 0.1 ft at stations 4 and 5. Some surging in water-surface elevation was still occurring at all stations approximately 140 min after the start of lock filling, with a change of 0.4 ft at station 2 being the largest recorded. Data presented in Plate 12 show that the velocities of the currents generated by filling both locks with a 10-min delay between the start of filling varied from a positive 1.1 to a negative 0.4 fps at station 1, a positive 1.9 to a negative 1.1 fps at station 2, and a positive 2.2 to a negative 1.5 fps at station 3. Approximately 130 min after the start of lock filling, the velocities of the currents were still fluctuating at station 3 from a positive 0.6 to a negative 0.6 fps.

Both locks filling, second lock delayed 20 min. When the start times of filling the locks were separated by 20 min, the magnitudes of surges in water-surface elevations were generally the same as those measured with a delay of 10 min except at station 1 (Plate 13). Filling the locks lowered the water-surface elevation about 1.4 ft at station 1, 1.1 ft at station 2, 0.8 ft at station 3, and 0.2-0.3 ft at stations 4 and 5. Depending on the station observed, a return surge occurred about 20 min after the start of filling the first lock. This surge raised the water-surface elevation about 0.9 ft over flat pool at station 1, 1.0 ft at station 2, 0.2 ft at station 3, and less than 0.1 ft at stations 4 and 5. Some surging in water-surface elevation was still occurring at all stations approximately 140 min after the start of lock filling with a change of about 0.4 ft being recorded at stations 1, 2, and 3. Data presented in Plate 14 show that the velocities of the currents generated by filling both locks with a 20-minute delay were generally less than those measured when the lock fillings were separated by 10 min. Filling the locks created velocities that varied from a positive 0.9 to a negative 0.1 fps at station 1, a positive 1.0 to a negative 0.5 fps at station 2, and a positive 2.2 to a negative 0.5 fps at station 3. Approximately 140 min after the start of lock filling, the velocities of the currents were still fluctuating at station 3 from a positive 0.4 to a negative 0.1 fps.

Both locks filling, second lock delayed 30 min. When the start times of filling the locks were separated by 30 min, the magnitudes of surges in water-surface and velocities were less than those measured when the two locks were filled simultaneously. However, the total response increased compared with 10- or 20-min delays of filling of the second lock. Data presented in Plates 15 and 16 show that delaying the filling of the second lock 30 min created a surge that interacted with the existing surge created by filling the first lock. This interaction created a larger surge than the other delay times. The maximum surge occurred about 35 min after the start time of filling the first lock. Filling the first lock initially lowered the water-surface elevation about 1.0 ft at station 1, 0.9 ft at station 2, 0.7 ft at station 3, and 0.3 ft at stations 4 and 5. A return surge occurred about 20 min after the start of filling. This surge raised the water-surface elevation about 1.2 ft at station 1, 1.0 ft at station 2, 0.5 ft at station 3, and 0.1-0.2 ft at stations 4 and 5. Filling the second lock lowered the water surface below flat pool 1.5 ft at station 1, 1.2 ft at station 2, 0.8 ft at station 3, and about 0.5 ft at stations 4 and 5. Some surging in water-surface elevation was still occurring at all stations approximately 140 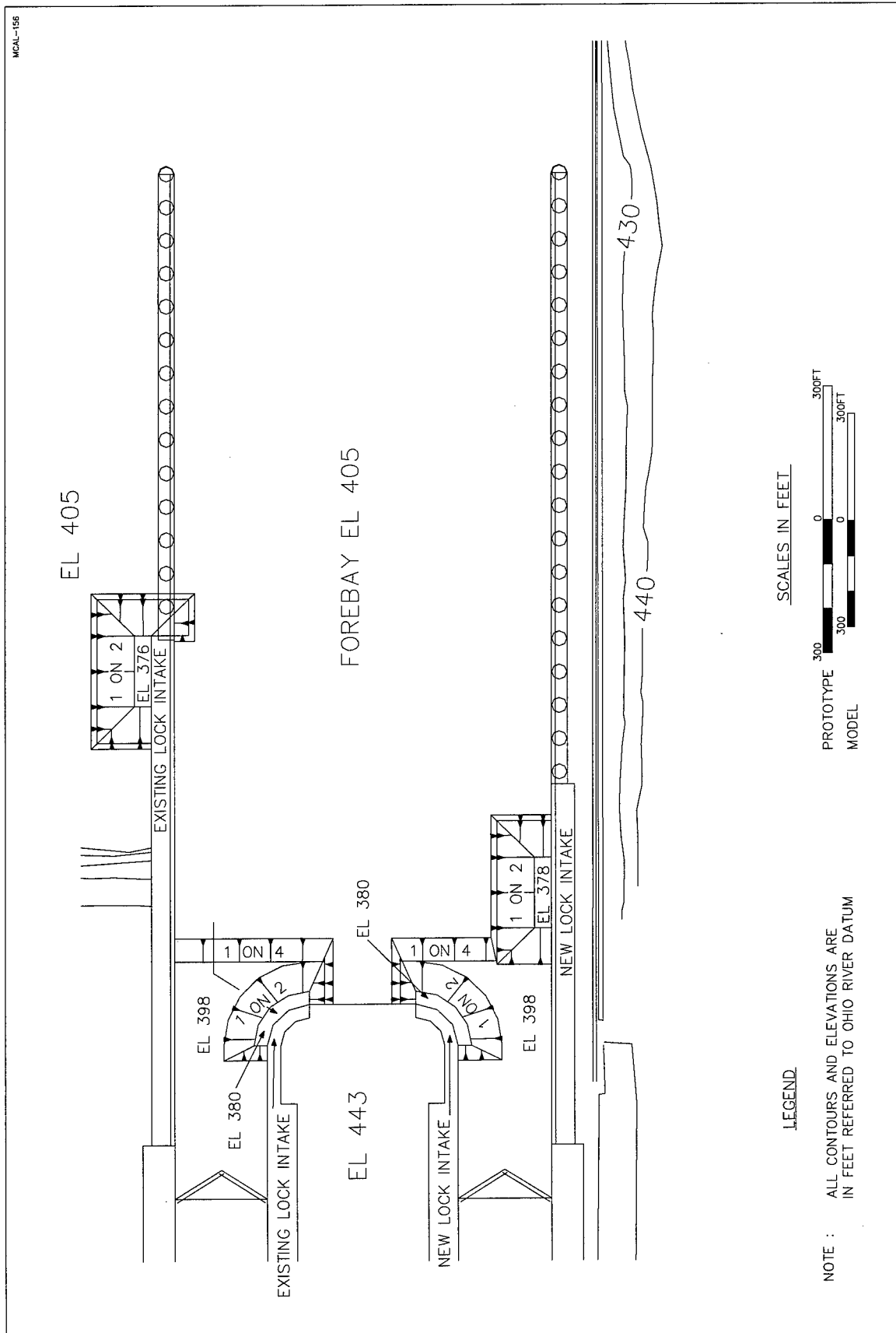min after the start of lock filling with a change of about 1.0 ft being recorded at station 1. Filling the locks created maximum velocities that varied from a positive 0.7 to a negative 0.3 fps at station 1, a positive 1.6 to a negative 1.1 fps at station 2, and a positive 2.6 to a negative 1.8 fps at station 3. Approximately 140 min after the start of lock filling, the velocities of the currents were still fluctuating at station 3 from a positive 0.6 to a negative 0.6 fps.

Dynamic tow experiments. Navigation conditions were satisfactory for tows entering and leaving the locks provided tows did not meet and pass in the L&P Canal (Plates 17-20). Downbound tows could enter the L&P Canal, align with the navigation span of the Conrail Railroad bridge, transit the canal, make the turn into the approach of the new lock, and land on the upper guide wall without any major difficulties. However, the clearance between the tow and the piers of the navigation span of the railroad bridge was small, and the tow occupied most of the canal as it turned to align with the guide wall of either lock (Plates 17 and 18). An upbound tow could be lying on the guide wall of the opposite lock as the downbound tow approached the guide wall of the other lock. Upbound tows could leave the lock and navigate through the railroad bridge without any difficulties. However, the tow occupied most of the canal when turning from the lock approach into the canal (Plates 19 and 20). The alignment of the left bank of the canal in the bend immediately upstream of the new lock was satisfactory for tows entering and leaving the new lock.

Navigation conditions for tows transiting the L&P Canal during lock filling could be hazardous. Downbound tows approaching the railroad bridge or either of the guide walls for the locks could be moved into the structures with considerable force due to the unexpected acceleration of the currents in the canal. Downbound tows navigating in an area 2,000 ft upstream of the guide walls and 1,000 ft downstream of the railroad bridge would experience surging in the velocities of the currents. However, they could probably maintain control of the vessel without any major difficulties provided no other tows are moving in the canal. Upbound tows would experience some surging in the velocities of the

currents in the canal but could probably maintain control and navigate the canal safely. However, some difficulty could occur if a major surge occurred when an upbound tow was navigating through the railroad bridge.

Static tow experiments. Experiments were conducted to evaluate the effects of lock filling and emptying on tows in the L&P Canal during lock filling. A tow was placed at three locations along the path and at the expected orientation of a tow navigating the canal, and a lock filling cycle was executed. During the lock filling cycle, the path and speed of the tow were recorded. Generally the tow moved downstream during the filling cycle, came to a stop as the surge reversed direction, and moved upstream with the surge. This movement was repeated several times as the surge continued in the canal. The tow obtained the greatest speed during the initial move downstream when the lock was filling. The tow paths and maximum speed are shown in Plates 21-29. A tow in the entrance to the L&P Canal during filling of a single lock would be moved downstream toward the railroad bridge at a speed of 1.6 to 1.9 fps (Plates 21 and 22). During a simultaneous filling of both locks, the tow would be moved downstream toward the railroad bridge at a speed of about 4.9 fps (Plate 23). These experiments show the speed of an underway tow could also be accelerated 1.6 to 1.9 fps during a single lock filling or 4.9 fps during a simultaneous filling of both locks. A tow at Surge Station 2 was moved downstream at 4.0 fps during a single lock filling and 5.1 fps during simultaneous filling of both locks (Plates 24-26). A tow placed in the canal about 2,000 ft upstream of the guide walls was moved downstream toward the locks at a speed that varied from 1.7 to 2.2 fps by a single lock filling. The speed was influenced by the position of the tow in the canal and which lock was filling (Plates 27 and 28). A tow placed in the canal about 2,000 ft upstream of the guide walls when both locks were filled simultaneously was moved downstream toward the locks at about 3.1 fps (Plate 29).

Results of lock emptying experiments with Plan A, Scheme 1

Plan A, Scheme 1, provided a lock emptying system with a diffuser in the lower lock approach between the walls of the new 1,200-ft lock to carry one-half of the flow from lock emptying. The remaining one-half of the flow from lock emptying was routed through a culvert extending from the north wall of the new 1,200-ft lock. The culvert extended under the existing 1,200-ft lock and discharged through an existing discharge bucket into the back channel between the existing 1,200-ft lock and Sand Island (Figure 12). The locks were operated to simulate a 10-min emptying curve. Surges in water-surface elevation and velocities of currents created by lock emptying are shown in Plates 30-35.

Existing lock emptying. Emptying the existing lock created surges in water-surface elevation and velocities of currents similar to those produced with existing conditions. The maximum surge in water-surface elevation of about 0.7 ft was recorded at station 1 in the channel between the existing lock and Sand Island. Surges in water-surface elevation of less than 0.5 ft were recorded at stations 2, 3, and 4. Surges in velocities of the currents due to emptying the existing 1,200-ft lock are shown in Plate 31. These data show surges in velocities of

about 2.7 fps at station 1, 0.6 fps at stations 2 and 3, and 1.3 fps at station 4. Secondary surges were minor at all stations.

New lock emptying. The results of measurements made during emptying of the new 1,200-ft lock are shown in Plates 32 and 33. These data show that surges in water-surface elevation were generally the same as those measured during emptying of the existing lock. However, a slight change in the magnitude at station 2 was recorded. The maximum change in water-surface elevation was about 0.7 ft. Lock emptying created a surge in the current velocities of about 1.8 fps at station 1, 2.4 fps at station 2, 1.1 fps at station 3, and 0.9 fps at station 4.

Both locks emptying. Measurements made during simultaneous emptying of both locks are shown in Plates 34 and 35. Compared with existing conditions, these data show an increase in the magnitude of the velocities at station 1, where all of the existing lock and one-half of the new lock were discharging through the existing riverside buckets. However, this increase would not adversely affect navigation in the lower lock approach, which is protected by the riverside guard wall of the existing lock. The velocities of the currents at station 2 varied from a positive 1.8 fps to a negative 0.4 fps due to lock emptying for an overall change in velocities of 2.2 fps. A surge in the water-surface elevation of about 1.0 ft was measured at station 2.

Static tow experiments. Experiments were conducted to evaluate the effects of lock emptying on a tow placed in the lower lock approach. An untethered tow was placed at selected locations in the lower lock approach, and the path and speed of the tow were measured during the emptying cycle. A tow resting along the downstream guide wall of the new lock, either near the lock or at the midpoint of the wall, was moved downstream at a slow speed by emptying the existing lock (Plates 36 and 37). A tow resting along the downstream guard wall of the existing lock, either near the lock or the midpoint of the wall, was moved downstream at a slow speed with very little rotation (Plates 38 and 39). This condition is similar to conditions that existed in the field at the time of this study.

Emptying the new lock chamber created downstream flow along the new guide wall with a large clockwise eddy forming along the existing guard wall. When a tow was resting on either lower wall near the lock chamber, emptying the new lock affected the tow more than emptying the existing lock. This was due to the diffuser being located immediately downstream of the miter gate of the new lock and one-half of the lock discharge being directly upstream of the tow. A tow resting near the lock was moved downstream and rotated riverward during emptying of the new lock (Plate 40). After the lock was emptied, the tow was moved back toward the guide wall of the new lock. The initial movement of the tow would be difficult to control unless the tow was tied to a mooring bit. A tow resting on the guide wall of the new lock at about midpoint of the wall was moved downstream slowly without any major rotation of the tow (Plate 41). A tow resting on the guard wall of the existing 1,200-ft lock during emptying of the new lock chamber was rotated clockwise with very little movement downstream

(Plate 42). The rotation was slow and could be controlled without any major difficulty. A tow resting on the guard wall near the midpoint of the wall was moved downstream slowly without any major rotation (Plate 43).

Emptying both lock chambers simultaneously initially created downstream flow along the new guide wall and a clockwise eddy along the guard wall similar to emptying the new lock chamber. However, emptying the existing chamber and one-half of the new chamber into the channel between the locks and Sand Island increased the flow through the guard wall and into the lower approach of the locks. This flow reduced the size of the eddy and increased the downstream flow in the approach compared with emptying the new chamber. Data shown in Plates 44-47 indicate that a tow resting on either the guard wall or the guide wall near the lock chamber while both locks are emptied simultaneously would experience movements that would be difficult to control. A tow resting along the new guide wall near the lock chamber was moved downstream along the wall without much rotation. When the tow had moved downstream far enough to expose about half the tow to currents moving across the lower end of the guard wall, the tow was rotated counterclockwise (Plate 44). The initial movement downstream would be difficult to control. A tow resting along the new guide wall at about midpoint of the wall was moved downstream by the initial surge and rotated counterclockwise as it cleared the downstream end of the guide wall (Plate 45). The movement of the tow could be controlled without any major difficulty.

A series of experiments was conducted to evaluate the effects of lock emptying on a small boat waiting in the lower approach to the lock to lock through to the upper pool. The results of these experiments are shown in Plates 48 and 49. These data show that a small boat waiting near the downstream end of the new lock chamber when the lock was emptied would be moved downstream at a maximum speed of about 4.5 fps with considerable rolling motion. However, a small boat could wait at the midpoint of the new guide wall during lock emptying without any major difficulties (Plate 49).

Results of lock emptying experiments with Plan A, Scheme 2

Plan A, Scheme 2, was generally the same as Scheme 1. However, the diffuser in the lower lock approach immediately downstream of the miter gates of the new 1,200-ft lock was moved to the area between the existing and new locks (Figure 13). The diffuser still carried one-half of the flow from lock emptying. The remaining one-half of the flow from lock emptying was passed through a culvert extending from the north wall of the new 1,200-ft lock. The culvert extended under the existing 1,200-ft lock and discharged through an existing discharge bucket into the back channel between the existing 1,200-ft lock and Sand Island the same as with Plan A, Scheme 1.

Lock emptying. The results of measurements made with Scheme 2 are shown in Plates 50-53. These data show the surges in water-surface elevation and velocities were generally the same as with Scheme 1. However, the current pattern created by lock emptying was considerably different from Scheme 1 due

EXISTING LOCK

NORTH WALL
BUCKET

EL 443

NEW LOCK

EL 370

SOUTH WALL
DIFFUSER

SCALES IN FEET

PROTOTYPE 300 200 100 0 300

MODEL 3 2 1 0 3
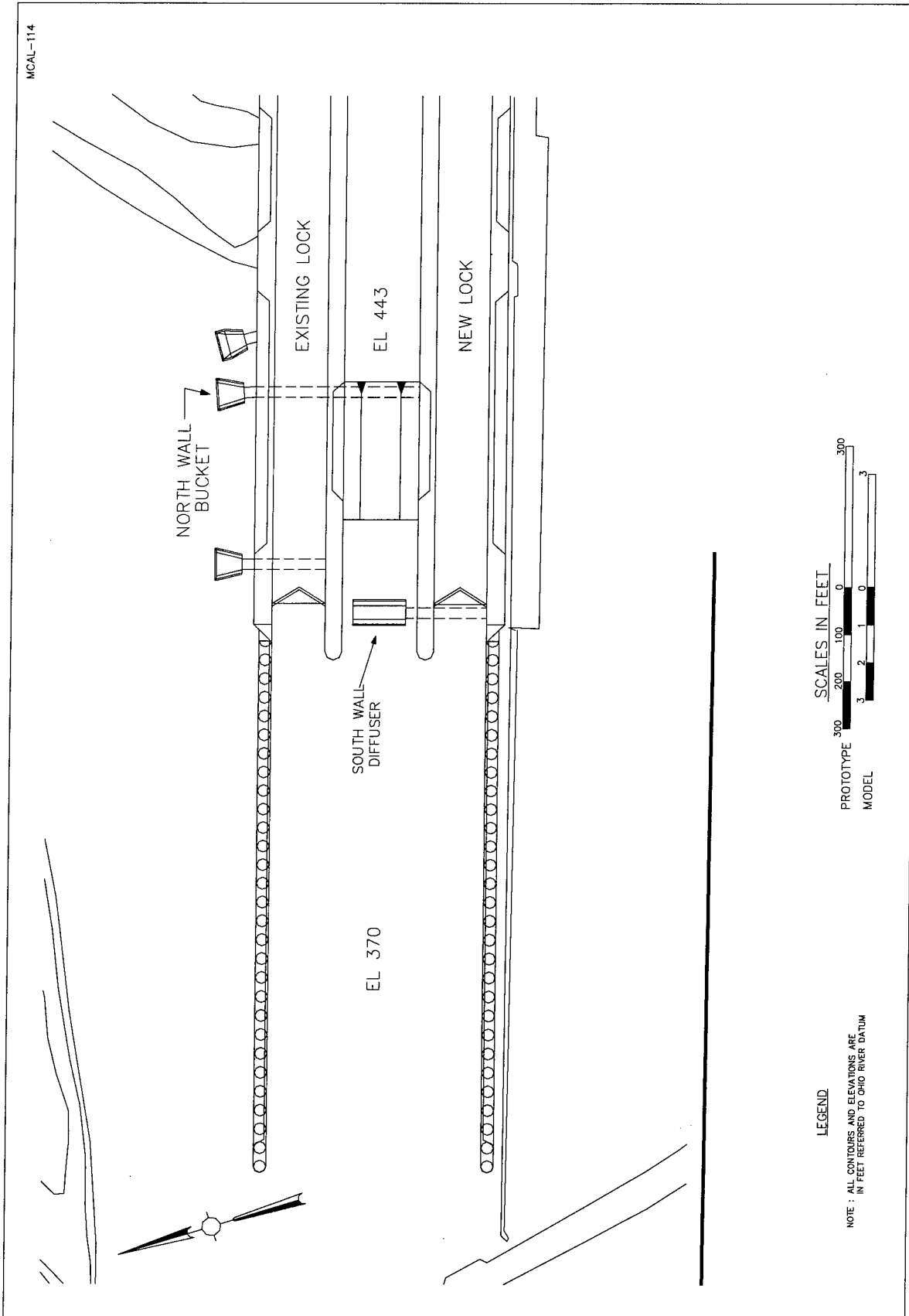
Figure 13.   Plan A, Scheme 2, emptying system

to the placement of the diffuser. Generally the flow was more evenly distributed across the lower approach than with Scheme 1. Emptying the new lock created a surge in the current velocities of about 1.8 fps at station 1, 2.0 fps at station 2, 1.0 fps at station 3, and 0.9 fps at station 4. Emptying both locks simultaneously created surges in velocities of about 3.1 fps at station 1, 2.3 fps at station 2, 1.4 fps at station 3, and 1.6 fps at station 4.

Static tow experiments. Results of static tow experiments are shown in Plates 54-61. These experiments show that the effects of surges created by emptying the new 1,200-ft lock on tows in the lower lock approach were less than those with Scheme 1. The flow from the diffuser between the locks was more evenly distributed across the lower approach and did not directly affect a tow waiting on either the riverside or landside wall. The flow moved the tow downstream at a slow speed with minimal turbulence. The influence of lock emptying on a tow in the lower lock approach was generally the same when both locks were emptied simultaneously except when the tow was waiting on the riverside wall near the lock chamber (Plate 60). The increased flow through the riverside guard wall due to both locks emptying in the river moved the tow away from the wall and rotated it clockwise. The downstream movement was generally less than 2.0 fps and could be controlled without any major difficulties.

Results of experiments to evaluate the effects of lock emptying on a small boat waiting in the lower approach to lock through to the upper pool are shown in Plates 62-69. These data show that a small boat waiting near the downstream end of the new lock chamber when the lock was emptied could be moved either downstream (Plate 62) or upstream into the flow from the diffuser (Plate 66). This could create a hazardous situation for small boats. However, if the small boat waited further downstream at the midpoint of the wall, downstream movement was less and did not present any major difficulties (Plates 63 and 67). There was a tendency for lock emptying to move the boat away from the riverside wall (Plates 64 and 65). However, the turbulence and the pitching and rolling of the boat were minimal.

Results of lock emptying experiments with Plan A, Scheme 3

Scheme 3 of Plan A was generally the same as Scheme 2 of Plan A. However, two diffusers were in the area between the new and existing locks. These diffusers carried all of the flow from the new 1,200-ft lock, and the river discharge bucket was not used (Figure 14).

New lock emptying. Data presented in Plates 70-73 show that discharging all of the flow from emptying the new lock in the lower approach of the locks increased the surges in water-surface elevation and velocities compared with Schemes 1 and 2. However, the flow was evenly distributed across the lower approach except near the lock chambers. Water-surface elevation was increased about 1.0 ft at station 2, 0.8 ft at station 3, and 0.4 ft at station 4 due to emptying the new lock (Plate 70). Surges in velocities were measured to be about positive 3.4 fps at station 2, positive 1.5 fps at station 3, and positive 1.2 fps at station 4 (Plate 71).

MCAL-115

EXISTING LOCK

EL 443

NEW LOCK

NORTH WALL
DIFFUSER

SOUTH WALL
DIFFUSER

EL 370

LEGEND

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 300 200 100 0 100 200 300

MODEL 3 2 1 0 1 2 3
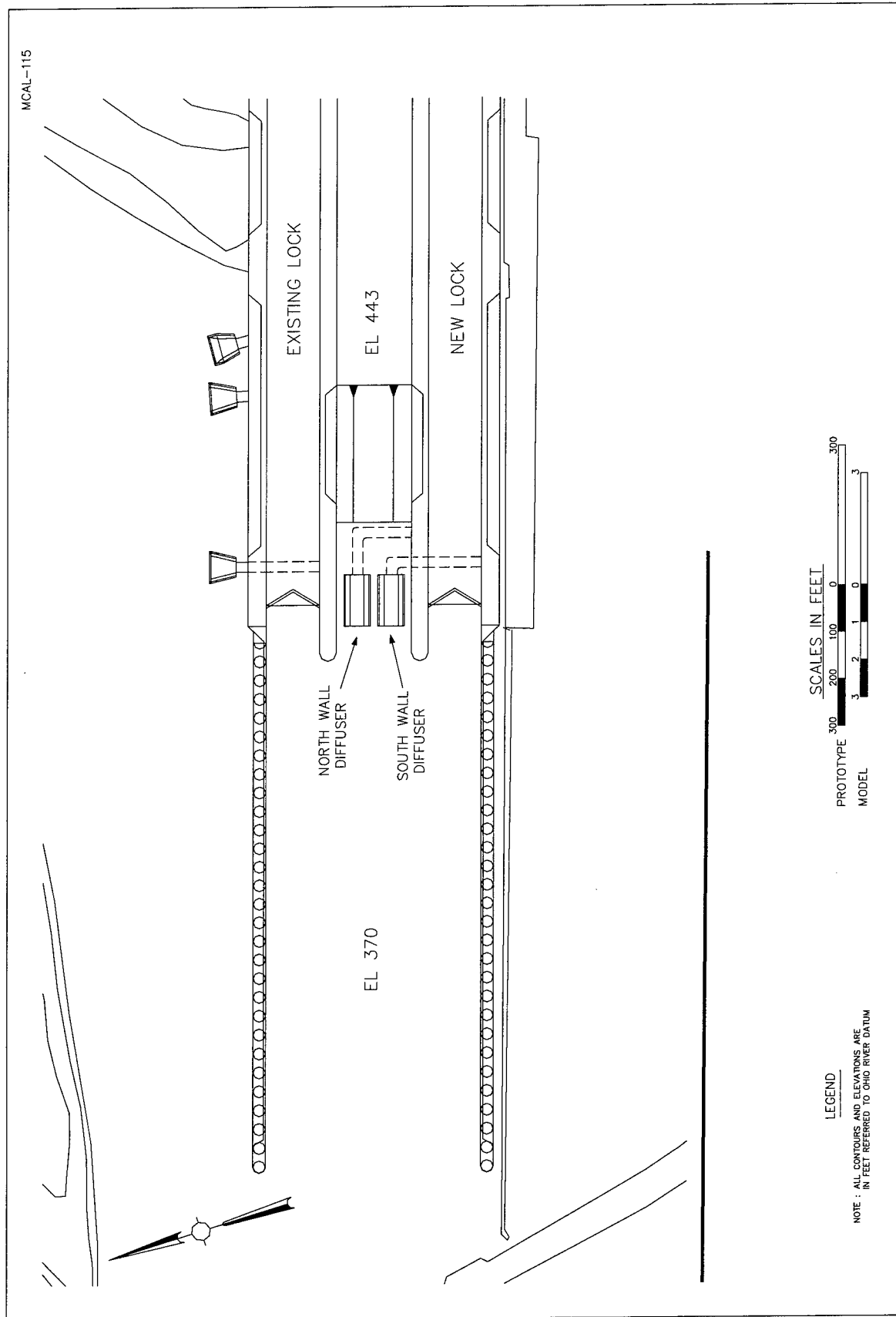
Figure 14.   Plan A, Scheme 3, emptying system

Both locks emptying. Surges in water-surface elevation and velocities were about the same when both locks were simultaneously emptied except at stations 1 and 4, which were influenced by emptying the existing chamber in the channel between the locks and Sand Island.

Static tow experiments. Results of static tow experiments are shown in Plates 74-81. These experiments show that the effects of surges created by emptying the new 1,200-ft lock on tows in the lower lock approach were generally the same as with Scheme 2. The flow from the diffusers between the locks was evenly distributed across the lower approach and did not directly impact a tow waiting on either the riverside or landside wall. The flow moved the tow downstream at a slow speed with a minimum amount of turbulence. The influence of lock emptying on a tow in the lower lock approach was generally the same when both locks were emptied simultaneously. The downstream movement was generally less than 2.0 fps and could be controlled without any major difficulties.

Results of experiments to evaluate the effects of lock emptying on a small boat waiting in the lower approach to lock through to the upper pool are shown in Plates 82-89. These data show that a small boat waiting at any point along the landside guide wall when the new lock was emptied moved downstream along the wall at less than 2.0 fps with a minimum amount of pitch or roll (Plates 82 and 83). A small boat waiting at the midpoint of the guard wall when the new lock was emptied moved downstream along the wall at less than 2.0 fps with a minimum amount of pitch or roll (Plate 85). A small boat waiting near the downstream end of the existing lock when the new lock was emptying could be moved out into the flow from the diffusers by the flow moving beneath the guard wall (Plate 84). However, the boat was moved downstream at less than 2.0 fps and with a minimum amount of pitching and rolling. A small boat could control the movement by tying to the wall or by using some power. Conditions for small boats in the lower lock approach were generally the same when both locks were emptied simultaneously (Plates 86-89).

Plan B Experiments

Description

Plan B was the same as Plan A, except the L&P Canal was dredged to project depths near the railroad bridge, and part of the lower guide wall of the new lock was removed. The guide wall was 640 ft long with the downstream end at station 39+90. Early in the study, excavation of the left bank of the canal immediately upstream of the lock was proposed as a feature of Plan B to provide additional maneuvering area for tows entering and leaving the new lock. However, in the preliminary design phase of the study the new lock was moved about 50 ft north of the originally proposed location, providing better alignment with the existing left bank. The relocated lock was a part of Plan A, and navigation experiments with that plan indicated additional excavation of the left bank in the bend was not necessary.

Results of lock filling experiments

Experiments were conducted to record surges in water-surface elevation and current velocities. These data are shown in Plates 90-93. These data show that the surges in water-surface elevation and velocities were generally the same as Plan A surges, except those at station 3, where the surges were less.

Filling one lock. The initial surge in water-surface elevation due to filling one lock decreased the water surface about 1.1 ft at stations 1 and 2, 0.6 ft at station 3, and 0.3 ft at stations 4 and 5 (Plate 90). The velocity of the currents due to lock filling varied from about a positive 0.9 fps to a negative 0.5 fps at station 1, a positive 1.4 fps to a negative 0.8 fps at station 2, and a positive 1.4 fps to a negative 1.0 fps at station 3 (Plate 91).

Both locks filling. Filling both locks simultaneously decreased the water-surface elevation about 2.6 ft at station 1, 2.0 ft at station 2, 1.1 ft at station 3, and 0.6 ft at stations 4 and 5 (Plate 92). The velocity of the currents created by lock filling varied from about a positive 2.0 to a negative 0.8 fps at station 1, a positive 2.5 to a negative 1.5 fps at station 2, and a positive 3.0 to a negative 1.9 fps at station 3 (Plate 93).

Static tow experiments. Static tow experiments show that the path and speed of the tow were generally the same as with Plan A. Dredging near the railroad bridge did not significantly reduce the acceleration of a tow in the canal due to lock filling. However, the lower velocity of the currents should reduce the maneuvering required for the tow to navigate through the bridge.

Results of lock emptying experiments

Lock emptying experiments were conducted with two diffusers in the area between the new and existing locks, the same as with Plan A, Scheme 3. Dye, confetti, and the movement of an untethered tow during lock emptying were observed to evaluate the effects of lock emptying on navigation in the lower lock approaches. These experiments showed that shortening the new guide wall did not adversely affect navigation in the lower lock approach.

4 Results and Conclusions

Limitations of Model Results

Analysis of the results of this investigation is based on a study of the effects of various plans and modifications on water-surface elevations and current directions and velocities and the effects of the resulting currents on model towboat and tow behavior.

The scale of the model allowed water-surface elevations to be measured to accuracies of ±0.1 ft prototype. Current velocities could be measured to accuracies of ±0.1 fps prototype. The model was a fixed-bed type and not designed to reproduce overall sediment movement that might occur in the prototype with the various plans. Therefore, changes in channel form resulting from scouring and deposition and any resulting changes in current directions and velocities were not evaluated.

Summary of Results and Conclusions

Lock filling experiments show that some major difficulties could occur for tows transiting the L&P Canal if the locks are filled while the tows are in the area. Downbound tows could experience hazardous navigation conditions if either or both of the locks are filled when the tow is approaching the railroad bridge. The experiments show that the velocity of the currents would vary from 0 to 3.8 fps in as little as 10 min in this region and would significantly increase the speed of the tow. Depending on the location and orientation of the tow when the surge occurred, there was a tendency for the tow to be moved into the left bank or the upstream protection cells of the navigation span of the bridge.

Operational procedures could reduce the surges caused by lock filling and improve navigation conditions but could not eliminate all adverse effects on navigation in the L&P Canal. The timing of the operational procedures would be critical and, therefore, is not recommended as a solution to the problem.

Dredging the L&P Canal near the railroad bridge (Plan B) would not eliminate the adverse effects of lock filling on tows navigating the L&P Canal.

Plan A, Scheme 1, emptying system created adverse conditions for a tow waiting on the landside guide wall immediately downstream of the lock during emptying of the new lock. The tow was moved downstream and rotated riverward during emptying and then moved back toward the guide wall of the new lock. The initial movement of the tow would be difficult to control unless the tow was tied to a mooring bit.

Tows could wait at the midpoint of the landside guide wall during emptying of the new lock without any major difficulties.

Small boats could not wait immediately downstream of the new lock during emptying of the lock. The boat would be moved downstream and would pitch and roll due to the turbulence in the area. However, the small boat could wait at the midpoint of the wall without any difficulty.

Plan A, Scheme 2, emptying system provided satisfactory conditions for tows waiting on either the landside or riverside walls during lock emptying. However, small boats waiting near the downstream end of the new lock could be moved upstream into the discharge from the diffuser, which could create a hazardous situation.

Although the Plan A, Scheme 3, emptying system created the highest surge in velocities in the lower approach of the three plans, the flow was evenly distributed across the lower approach. The effects of lock emptying was generally the same as with Scheme 2.

The shorter downstream guidewall for the new lock (Plan B) provided satisfactory navigation conditions for tows entering and leaving the lower lock approach.
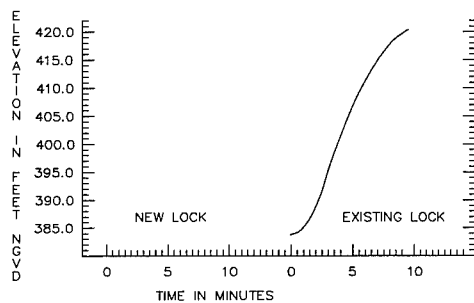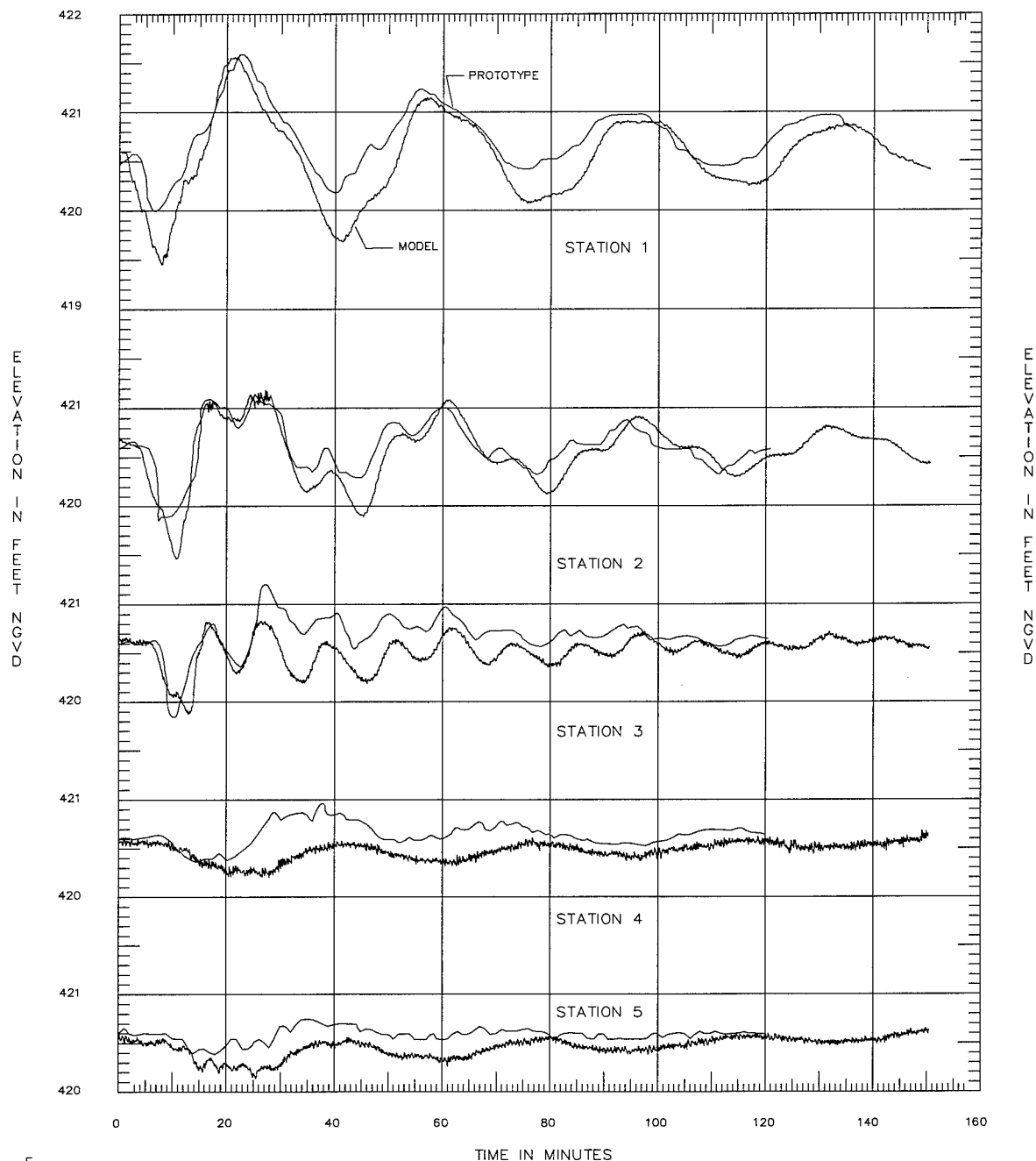
MCAL—030

WATER-SURFACE SURGES
LOCK FILLING
EXISTING CONDITIONS

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 1

VELOCITY IN FEET PER SECOND

STATION 1

PROTOTYPE

STATION 2

STATION 3

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK   EXISTING LOCK

TIME IN MINUTES
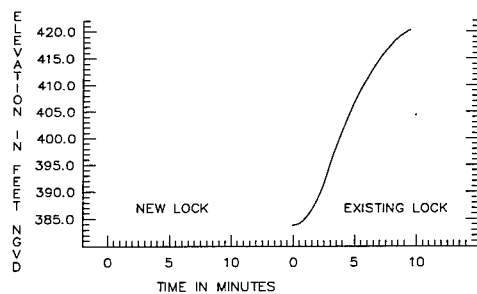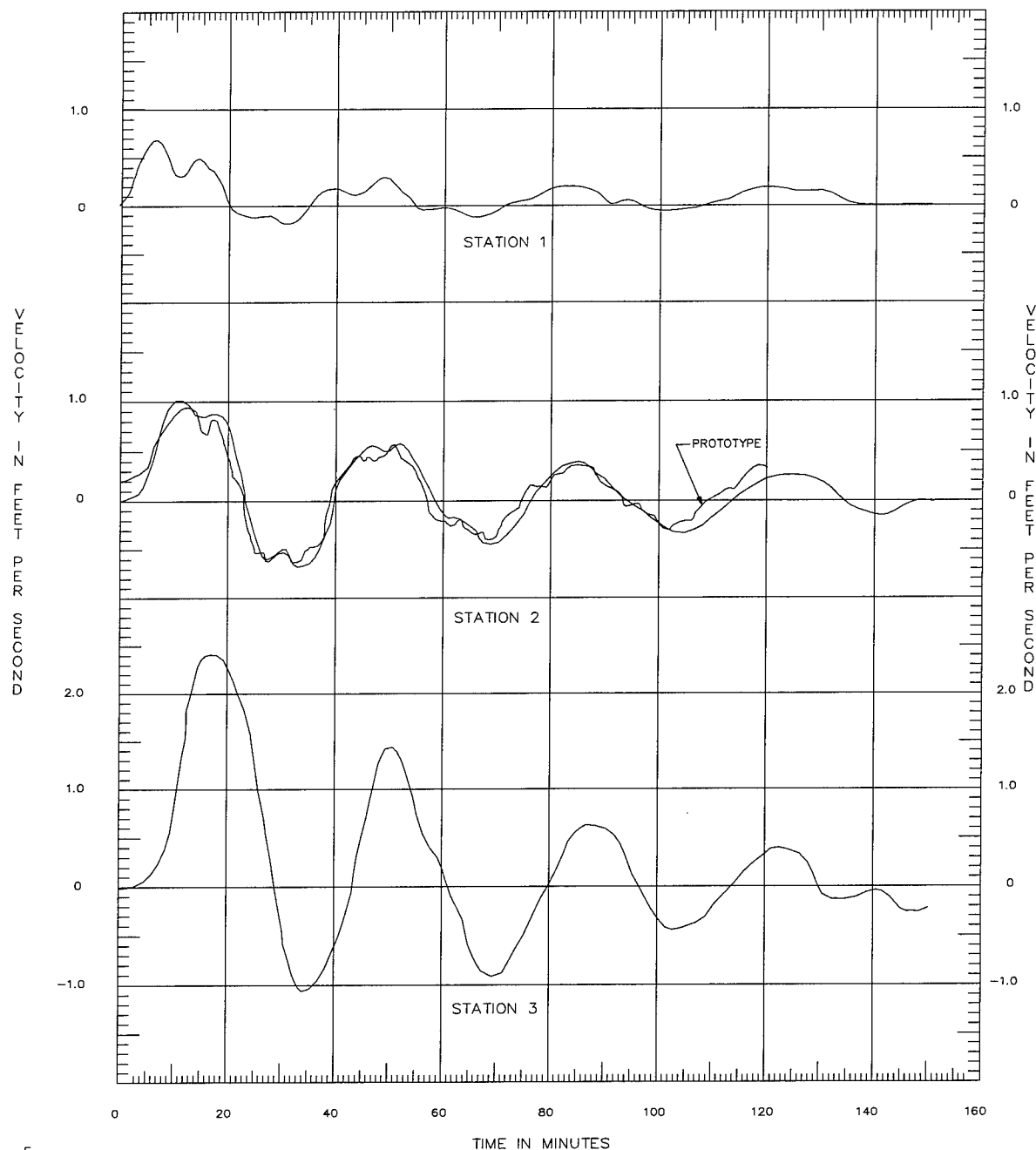
VELOCITY SURGES
LOCK FILLING
EXISTING CONDITIONS

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 2
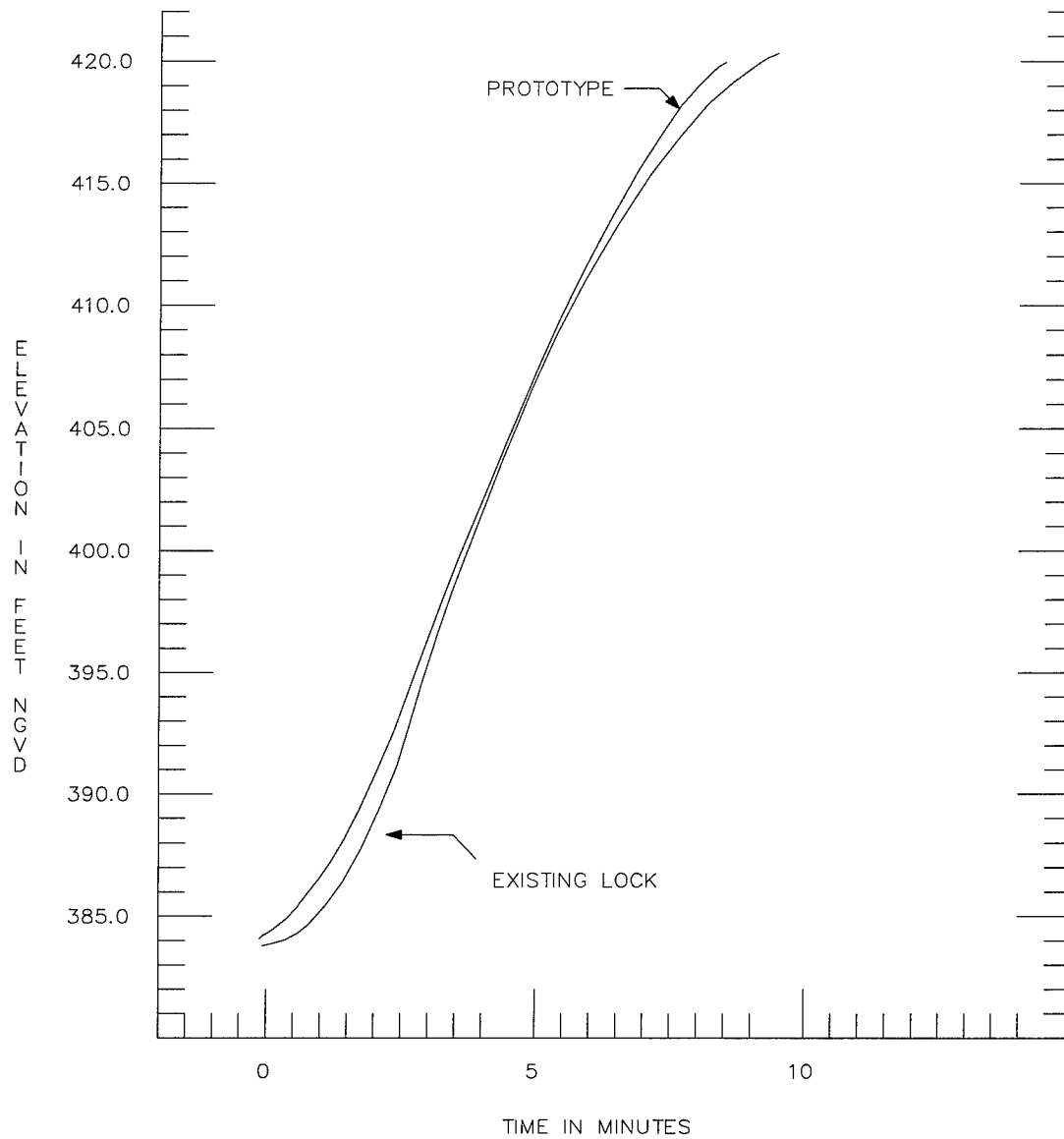
WATER-SURFACE ELEVATION

EXISTING LOCK FILLING

EXISTING CONDITIONS

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 3

WATER-SURFACE ELEVATION

EXISTING LOCK EMPTYING

EXISTING CONDITIONS

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 4

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

WATER-SURFACE SURGES
LOCK EMPTYING
EXISTING CONDITIONS

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 5

VELOCITY IN FEET PER SECOND

4.0

2.0

STATION 1

2.0

0

STATION 2

2.0

0

STATION 3

2.0

0

STATION 4

0   5   10   15   20   25   30

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK

EXISTING LOCK

0   10   0   10

TIME IN MINUTES

VELOCITY SURGES
LOCK EMPTYING
EXISTING CONDITIONS

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 6

STATION 1

STATION 2

STATION 3

STATION 4

STATION 5

ELEVATION IN FEET NGVD

TIME IN MINUTES

NEW LOCK   EXISTING LOCK

TIME IN MINUTES

ELEVATION IN FEET NGVD

WATER-SURFACE SURGES
EXISTING LOCK FILLING
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 7

VELOCITY SURGES
EXISTING LOCK FILLING
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 8

WATER-SURFACE SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 0 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

MCAL−051

Plate 9

VELOCITY IN FEET PER SECOND

STATION 1

STATION 2

STATION 3

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 0 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 10

WATER-SURFACE SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 10 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 11

MCAL–103

STATION 1

STATION 2

STATION 3

VELOCITY IN FEET PER SECOND

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 10 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 12

WATER-SURFACE SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 20 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 13

VELOCITY IN FEET PER SECOND

1.0

0

STATION 1

1.0

0

STATION 2

2.0

1.0

0

STATION 3

-1.0

VELOCITY IN FEET PER SECOND

1.0

0

1.0

0

2.0

1.0

0

-1.0

0   20   40   60   80   100   120   140   160

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK   EXISTING LOCK

0   5   10   0   5   10

TIME IN MINUTES

VELOCITY SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 20 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 14

WATER-SURFACE SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 30 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 15

VELOCITY SURGES
BOTH LOCKS FILLING
2ND LOCK DELAYED 30 MIN.
PLAN A

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 16

TOW PATHS
APPROACHING NEW LOCK
PLAN A
DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6 FT

SCALES IN FEET

PROTOTYPE

MODEL

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
         IN FEET REFERRED TO OHIO RIVER DATUM

CONRAIL RAILROAD BRIDGE

MODEL LIMITS

Plate 17

TOW PATHS
APPROACHING EXISTING LOCK
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6 FT

SCALES IN FEET

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

MODEL LIMITS

CONRAIL RAILROAD BRIDGE

Plate 18

TOW PATHS
LEAVING NEW LOCK
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6 FT

CONRAIL RAILROAD BRIDGE

MODEL LIMITS

MCAL-136

N 2,283,000
E 1,568,000
E 1,563,000
N 2,281,000
E 1,560,000
N 2,285,000
N 2,286,000
E 1,561,000

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE
500   0   500   1000   1500   2000

MODEL
5   0   5   10   15   20   25

Plate 19

TOW PATHS
LEAVING EXISTING LOCK
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6 FT

SCALES IN FEET

PROTOTYPE
MODEL

CONRAIL RAILROAD BRIDGE

MODEL LIMITS

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM

Plate 20

MCAL-124

MOVEMENT OF TOW
DURING FILLING OF EXISTING LOCK
TOW AT ENTRANCE TO CANAL
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6   FT

SCALES IN FEET

PROTOTYPE 300   0   300FT

MODEL   300   0   300FT

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
          IN FEET REFERRED TO OHIO RIVER DATUM

1.6-FPS

430

440

430

440

Plate 21

MCAL-123

MOVEMENT OF TOW
DURING FILLING OF NEW LOCK
TOW AT ENTRANCE TO CANAL
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6 FT

SCALES IN FEET

PROTOTYPE   300   0   300FT

MODEL   300   0   300FT

1.9-FPS

430

430

440

440

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

Plate 22

MCAL-133

MOVEMENT OF TOW
DURING FILLING OF BOTH LOCKS
TOW AT ENTRANCE TO CANAL
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6   FT

430

440

430

440

4.9-FPS

SCALES IN FEET

PROTOTYPE   300   0   300FT

MODEL   0   300FT

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
          IN FEET REFERRED TO OHIO RIVER DATUM

Plate 23

Plate 24

SHIPPINGPORT ISLAND

440

4.0-FPS

430

SURGE STATION 2

MCAL-127

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 300   0   300FT

MODEL   300   0   300FT

MOVEMENT OF TOW
DURING FILLING OF EXISTING LOCK
TOW NEAR SURGE STATION 2
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6   FT

SHIPPINGPORT ISLAND

440

4.1-FPS

430

SURGE STATION 2

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   300   0   300FT
MODEL   300   0   300FT

MOVEMENT OF TOW
DURING FILLING OF NEW LOCK
TOW NEAR SURGE STATION 2
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6   FT

MCAL-126

Plate 25

MCAL-130

SHIPPINGPORT ISLAND

440

5.1-FPS

430

SURGE STATION 2

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM
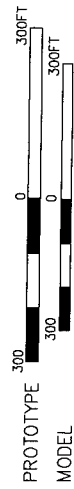
MOVEMENT OF TOW
DURING FILLING OF BOTH LOCKS
TOW NEAR SURGE STATION 2

PLAN A
DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6   FT

SCALES IN FEET

PROTOTYPE 300   0   300FT

MODEL   300   0   300FT

Plate 26

MCAL-125
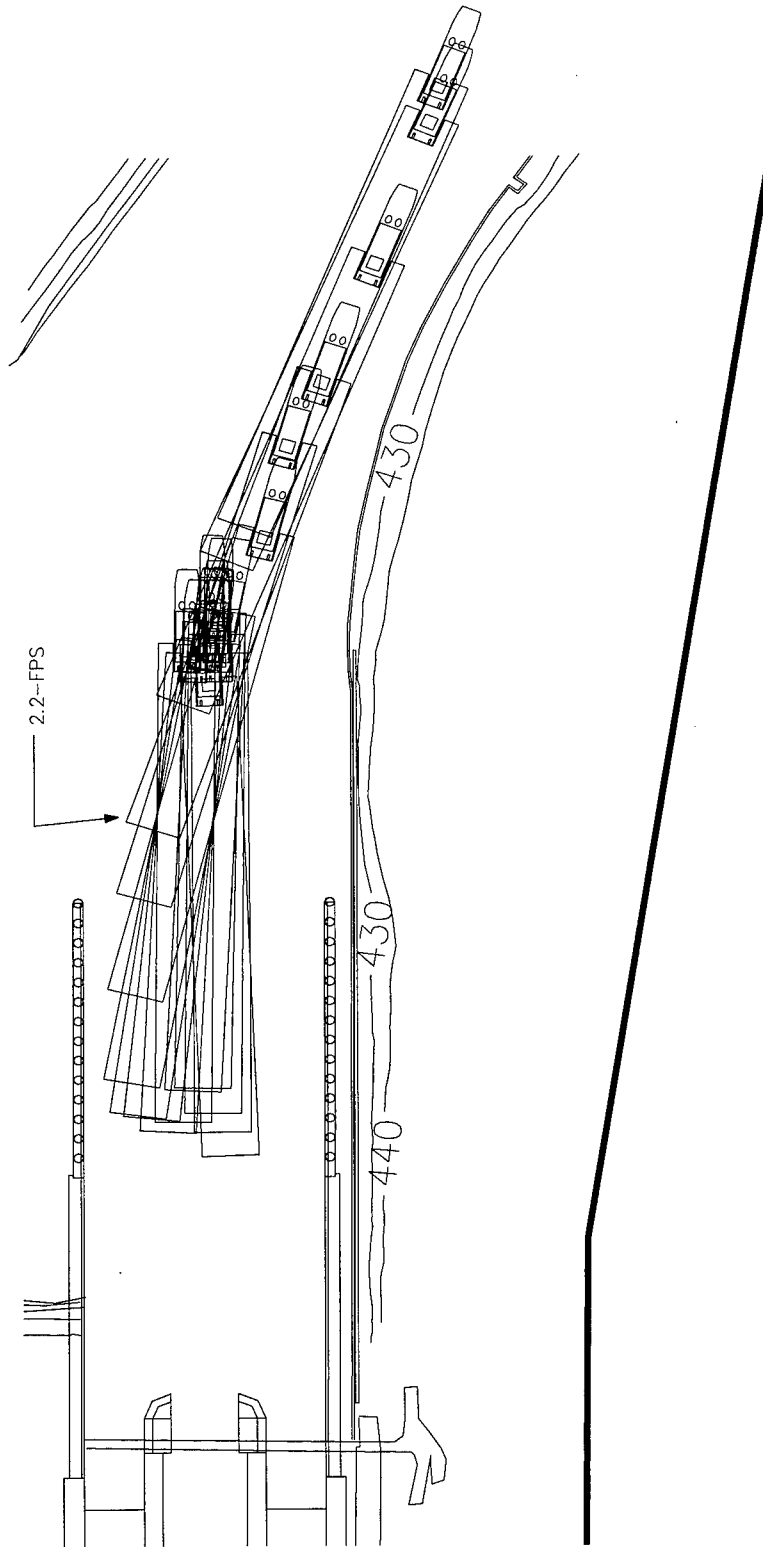
MOVEMENT OF TOW
DURING FILLING OF EXISTING LOCK
TOW 2,000 FT UPSTREAM OF GUIDE WALLS
PLAN A

DISCHARGE: 12,000 CFS
UPPER POOL EL: 420.6   FT

2.2~FPS

430

430

440

SCALES IN FEET

300   0   300FT
PROTOTYPE

300   0   300FT
MODEL

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
         IN FEET REFERRED TO OHIO RIVER DATUM

Plate 27

Plate 28

MCAL-128
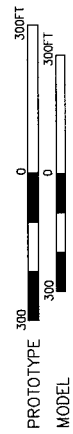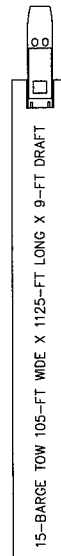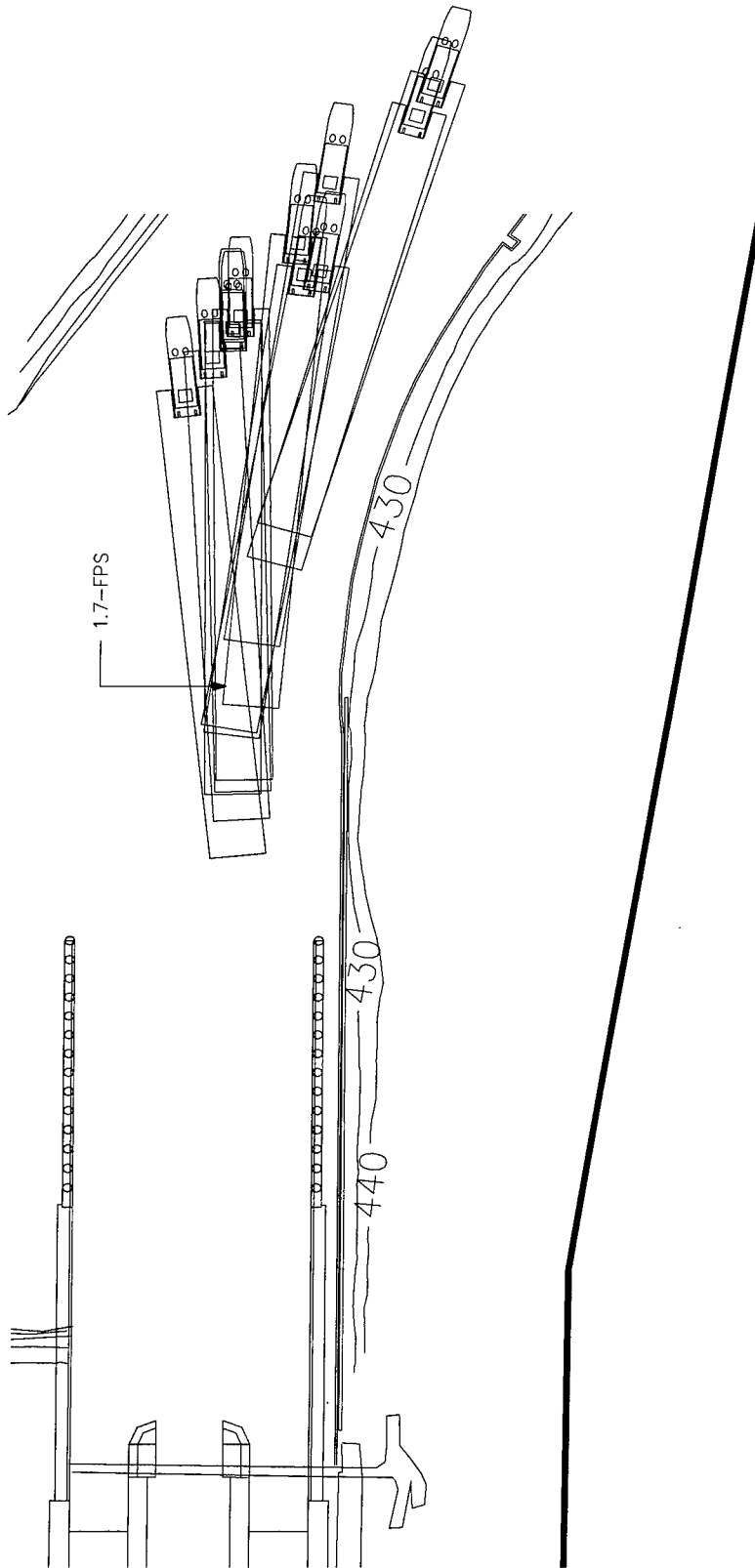
MOVEMENT OF TOW
DURING FILLING OF NEW LOCK
TOW 2,000 FT UPSTREAM OF GUIDE WALLS
PLAN A

DISCHARGE: 12,000   CFS
UPPER POOL EL: 420.6   FT

1.7—FPS

430

430

440

SCALES IN FEET

PROTOTYPE   300   0   300FT

MODEL   300   0   300FT

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
         IN FEET REFERRED TO OHIO RIVER DATUM

MCAL-129

3.1-FPS

430

430

440

LEGEND

15-BARGE TOW 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE :   ALL CONTOURS AND ELEVATIONS ARE
          IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   300   0   300FT
MODEL   300   0   300FT

MOVEMENT OF TOW
DURING FILLING OF BOTH LOCKS
TOW 2,000 FT UPSTREAM OF GUIDE WALLS
PLAN A

DISCHARGE: 12,000   CFS
UPPER POOL EL: 420.6   FT

Plate 29

WATER-SURFACE SURGES
EXISTING LOCK EMPTYING
PLAN A - SCHEME 1

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 30

STATION 1

STATION 2

STATION 3

STATION 4

VELOCITY IN FEET PER SECOND

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
EXISTING LOCK EMPTYING
PLAN A - SCHEME 1

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 31

WATER-SURFACE SURGES
NEW LOCK EMPTYING
PLAN A - SCHEME 1

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

MCAL–035

Plate 32

VELOCITY IN FEET PER SECOND

STATION 1

STATION 2

STATION 3

STATION 4

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES

NEW LOCK EMPTYING

PLAN A − SCHEME 1

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 33

ELEVATION IN FEET NGVD

385.0

384.0

STATION 1

385.0

384.0

STATION 2

385.0

384.0

STATION 3

385.0

384.0

STATION 4

0   5   10   15   20   25   30

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0

415.0

410.0

405.0

400.0

395.0

390.0

385.0

NEW LOCK

EXISTING LOCK

0   10   0   10

TIME IN MINUTES

WATER-SURFACE SURGES
BOTH LOCKS EMPTYING
PLAN A - SCHEME 1

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 34

STATION 1

STATION 2

STATION 3

STATION 4

VELOCITY IN FEET PER SECOND

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
BOTH LOCKS EMPTYING
PLAN A − SCHEME 1

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 35

MCAL-053

FLOW

FLOW

EXISTING LOCK

EL 443

NEW LOCK

425

430

425

425

0 MINUTES

13 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

SCALES IN FEET

PROTOTYPE 400 300 200 100 0   400

MODEL 5 4 3 2 1 0   5

MOVEMENT OF TOW
DURING EMPTYING OF EXISTING LOCK
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A – SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM

Plate 36

MCAL-056

FLOW

FLOW

EXISTING LOCK

EL 443

NEW LOCK

425

430

425

425

425

0 MINUTES

7 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF TOW
DURING EMPTYING OF EXISTING LOCK
TOW ON LANDSIDE OF WALL NEAR MID-POINT
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

SCALES IN FEET

PROTOTYPE   400 300 200   0   400

MODEL   5   4   3   2   1   0   5

Plate 37

MOVEMENT OF TOW
DURING EMPTYING OF EXISTING LOCK
TOW ON RIVERSIDE WALL NEAR LOCK
PLAN A – SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 38

MOVEMENT OF TOW
DURING EMPTYING OF EXISTING LOCK
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

6 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

430

425

425

SCALES IN FEET

PROTOTYPE   400 300 200 100 0

MODEL   5   4   3   2   1   0   400

MCAL-057

Plate 39

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A -SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 40

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON LANDSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 1

DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

430

425

425

425

SCALES IN FEET

PROTOTYPE   400 300 200 100 0   400

MODEL   5 4 3 2 1 0   5

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MCAL–060

Plate 41

MCAL-059

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON RIVERSIDE WALL NEAR LOCK
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

10 MINUTES

1 MINUTE TIME STEPS

SCALES IN FEET

PROTOTYPE   400 300 200 100   0   400

MODEL   5   4   3   2   1   0   5
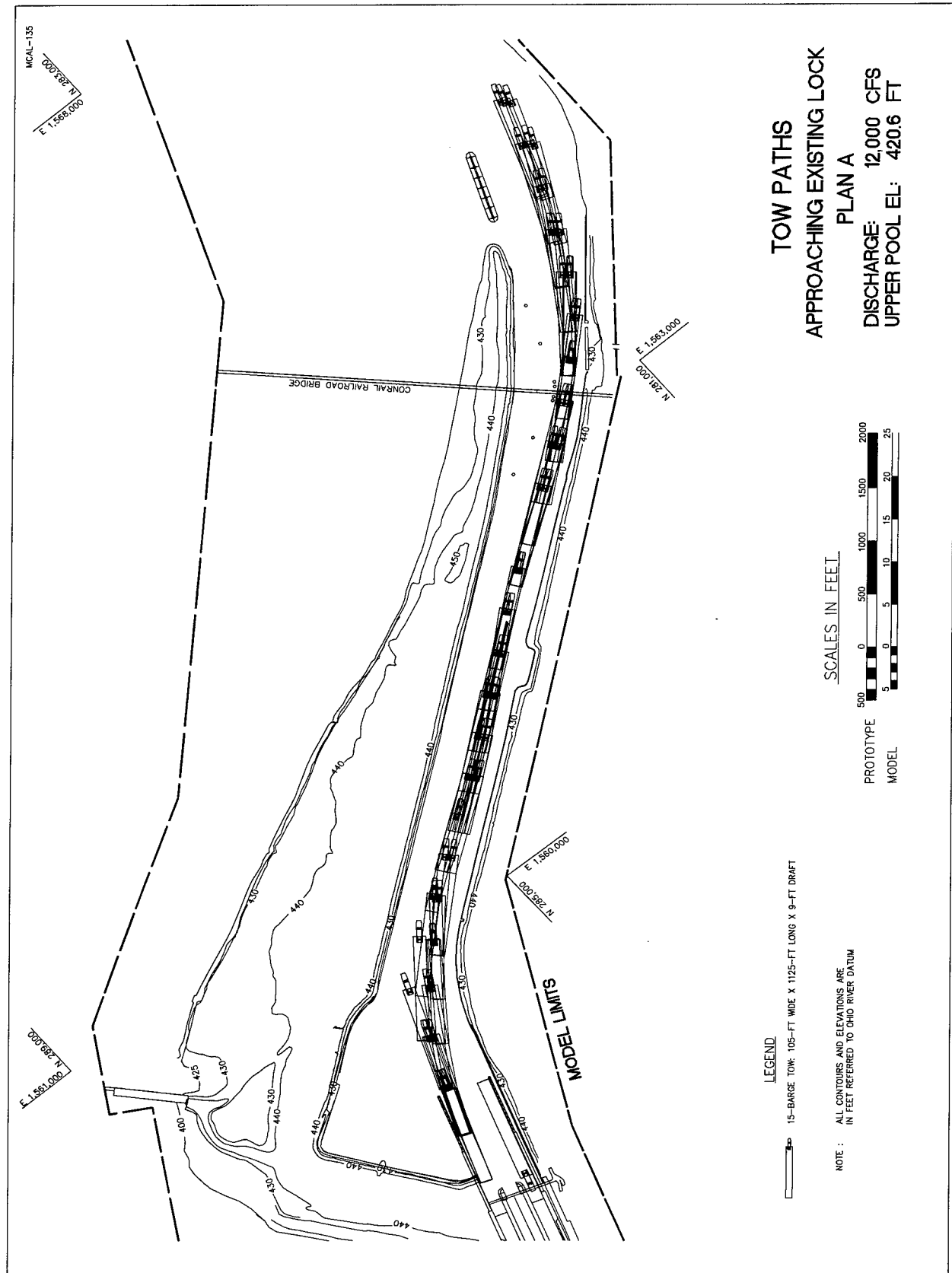
E 1,555,000

N 287,000

425

430

425

425

425

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM

Plate 42

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 1
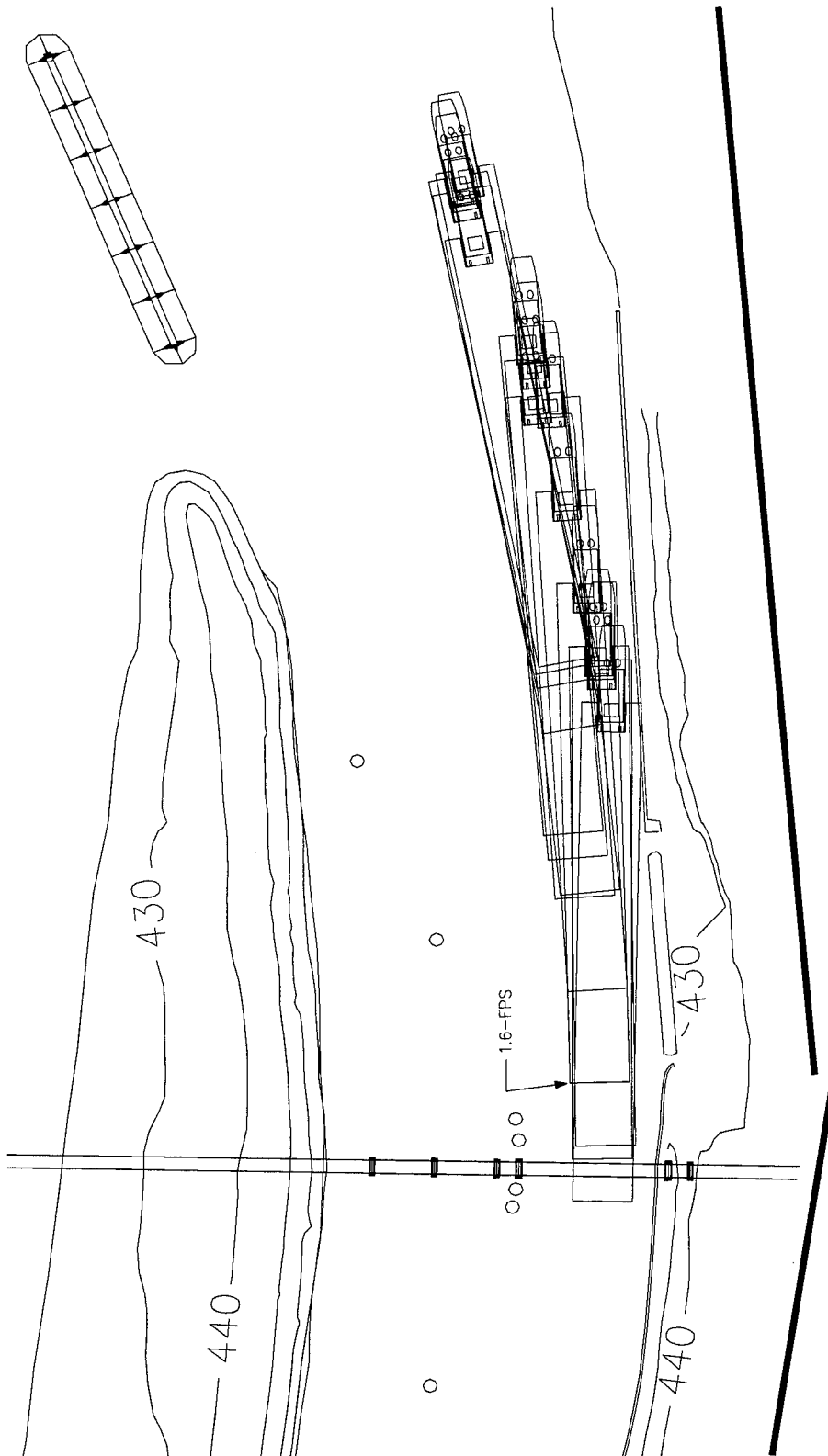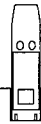
DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

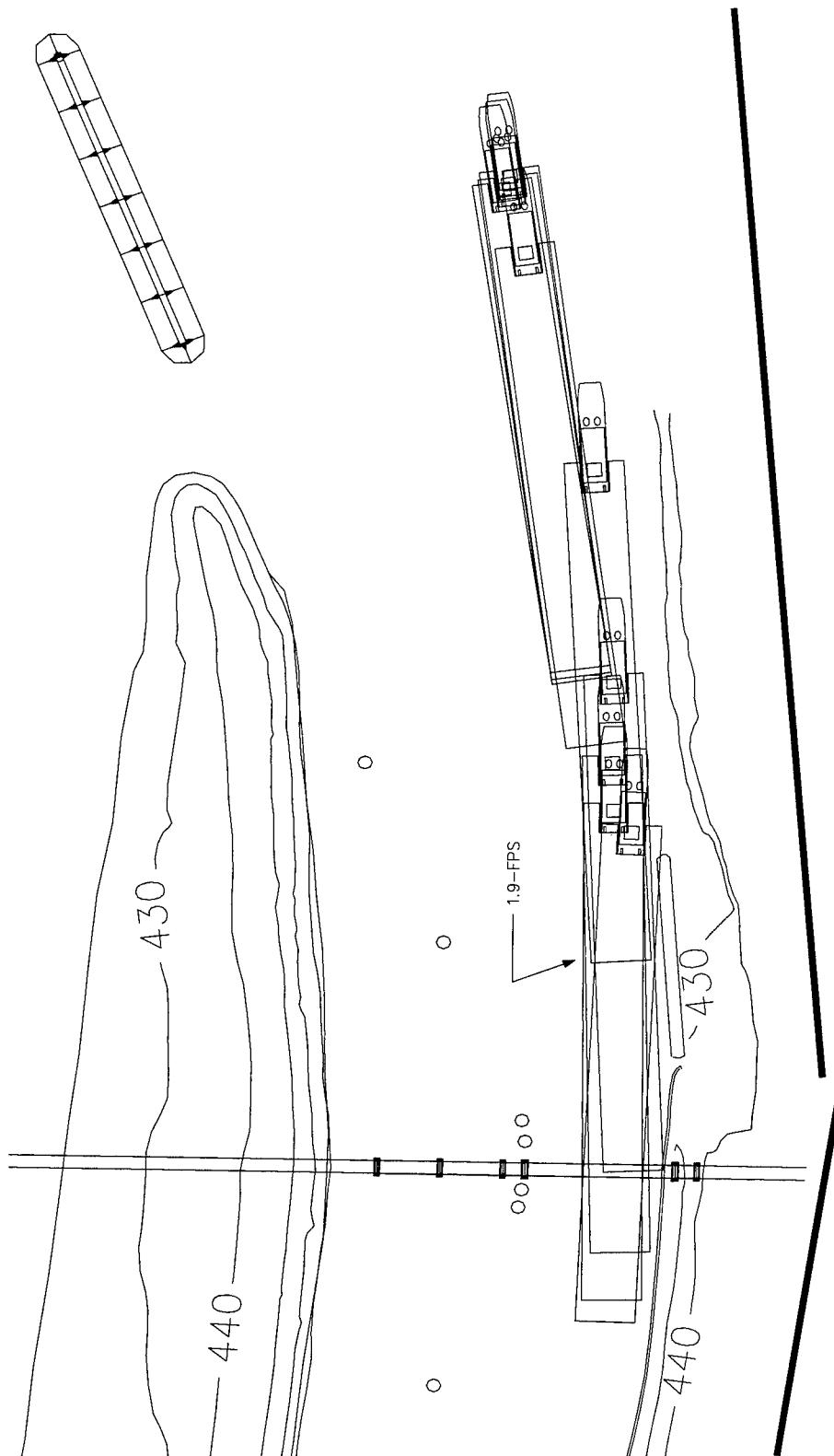NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400
MODEL   5   4   3   2   1   0   5

1 MINUTE TIME STEPS

0 MINUTES

4 MINUTES

FLOW

EXISTING LOCK

EL 443

NEW LOCK

FLOW

425

430

425

425

425

E 1,555,000

N 287,000

MCAL-061

Plate 43

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW
FLOW
FLOW
FLOW

425
430
425
425
425

0 MINUTES

7 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

SCALES IN FEET

PROTOTYPE   400 300 200 100   0   400

MODEL   5   4   3   2   1   0   5
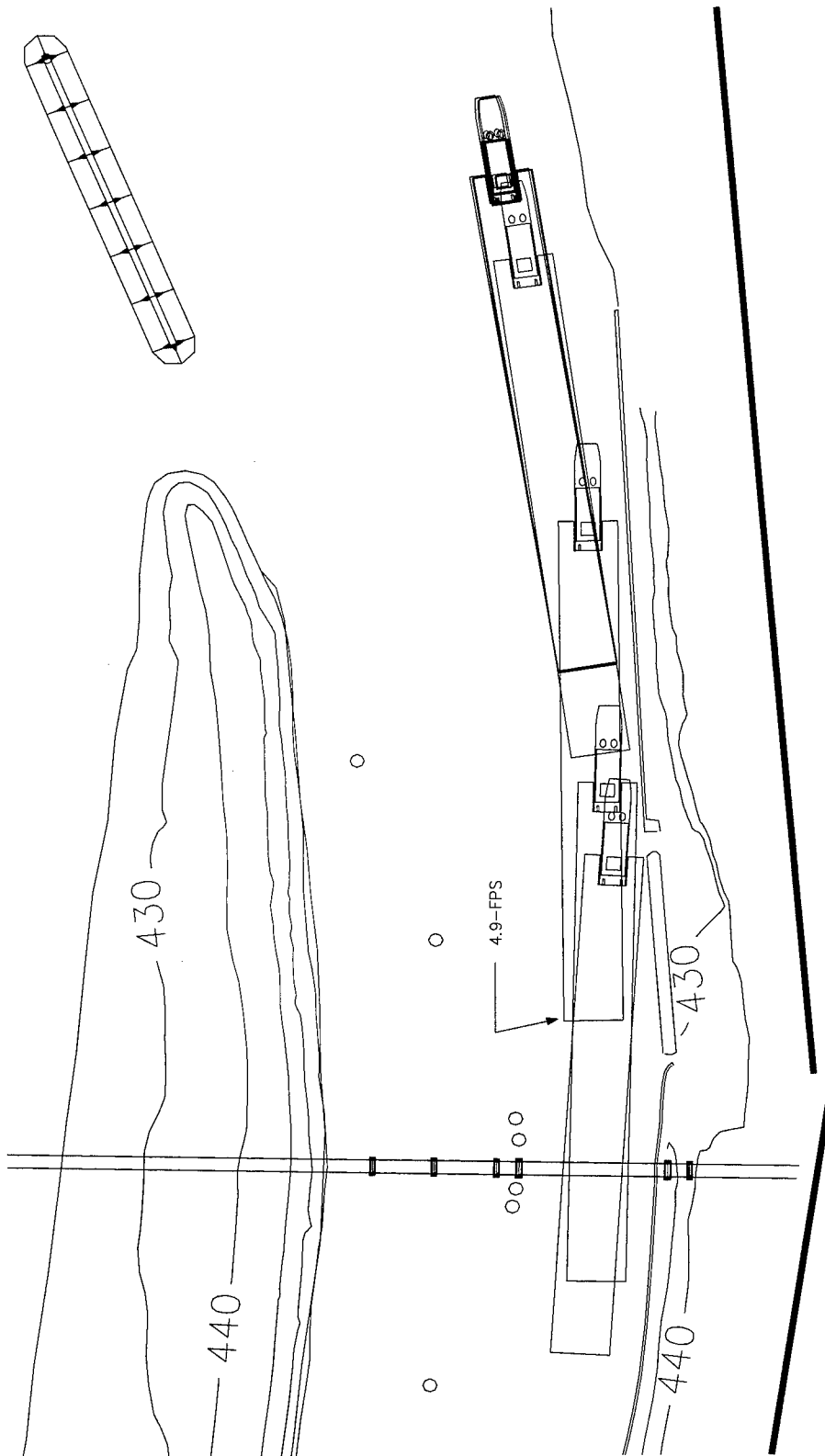
LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM

MCAL-049

Plate 44

MCAL-054

FLOW
FLOW
FLOW

EXISTING LOCK

EL 443

NEW LOCK

FLOW

425

430

425

425

0 MINUTES

10 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000
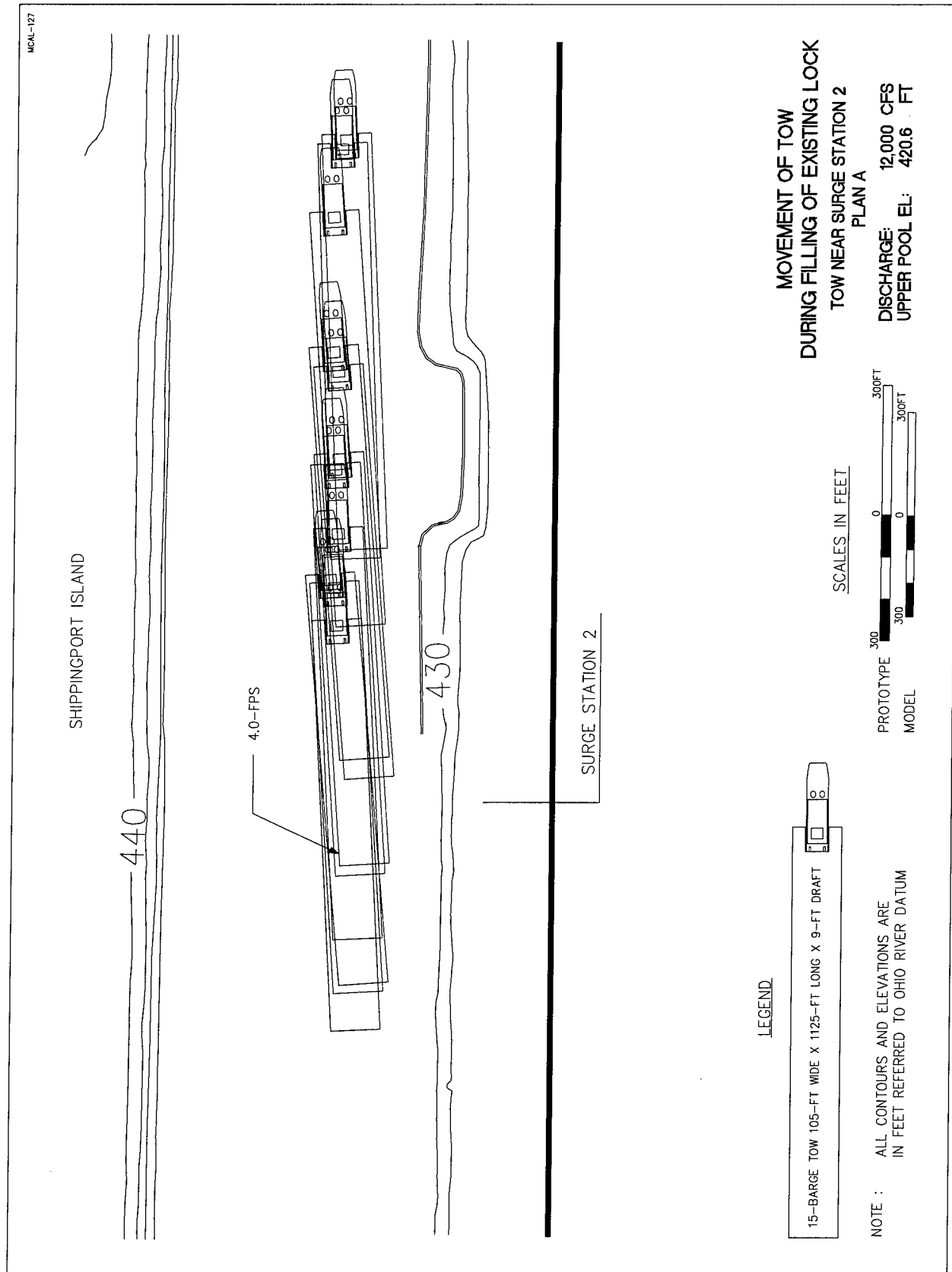
LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400 300 200 100 0   400

MODEL   5   4   3   2   1   0   5

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 45

MCAL-050

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON RIVERSIDE WALL NEAR LOCK
PLAN A – SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

FLOW

FLOW

0 MINUTES

9 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

SCALES IN FEET

PROTOTYPE 400 300 200 100 0 400
MODEL 5 4 3 2 1 0 5

425

430

425

425

LEGEND

15–BARGE TOW: 105–FT WIDE X 1125–FT LONG X 9–FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

Plate 46

MCAL-055

FLOW
FLOW
FLOW

EXISTING LOCK

EL 443

NEW LOCK

FLOW

425

430

425

425

0 MINUTES

5 MINUTES

E 1 MINUTE TIME STEPS

N 287,000

E 1,555,000

SCALES IN FEET

PROTOTYPE 400 300 200 100 0 400

MODEL 5 4 3 2 1 0 5

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 47

MCAL-078

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON LANDSIDE WALL NEAR LOCK
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 48

MCAL-087

EXISTING LOCK

FLOW

EL 443

NEW LOCK

FLOW

425

430

425

425

425

N 287,000

E 1,555,000

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

SCALES IN FEET

PROTOTYPE
400   300   200   100   0   400

MODEL
5   4   3   2   1   0   5

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 1

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 49

STATION 1

STATION 2

STATION 3

STATION 4

ELEVATION IN FEET NGVD

ELEVATION IN FEET NGVD

TIME IN MINUTES

NEW LOCK

EXISTING LOCK

ELEVATION IN FEET NGVD

TIME IN MINUTES

WATER-SURFACE SURGES
NEW LOCK EMPTYING
PLAN A – SCHEME 2

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 50

VELOCITY SURGES
NEW LOCK EMPTYING
PLAN A - SCHEME 2

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 51

STATION 1

STATION 2

STATION 3

STATION 4

ELEVATION IN FEET NGVD

385.0
384.0

385.0
384.0

385.0
384.0

385.0
384.0

TIME IN MINUTES

0   5   10   15   20   25   30

NEW LOCK

EXISTING LOCK

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

TIME IN MINUTES

0   10   0   10

WATER-SURFACE SURGES
BOTH LOCKS EMPTYING
PLAN A - SCHEME 2

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 52

STATION 1

STATION 2

STATION 3

STATION 4

VELOCITY IN FEET PER SECOND

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
BOTH LOCKS EMPTYING
PLAN A – SCHEME 2

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 53

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A - SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 54

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 55

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON RIVERSIDE WALL NEAR LOCK
PLAN A – SCHEME 2

DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

1 MINUTE TIME STEPS

11 MINUTES

E 1,555,000

N 287,000

SCALES IN FEET

PROTOTYPE 400 300 200 100 0 400
MODEL 5 4 3 2 1 0 5

MCAL-67A

Plate 56

MCAL-065

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

425

430

425

425

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400 300 200 100 0   400

MODEL   5   4   3   2   1   0   5

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 57

MCAL-066

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A – SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 400 300 200 100 0

MODEL 5 4 3 2 1 0

1 MINUTE TIME STEPS

0 MINUTES

8 MINUTES

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

FLOW

FLOW

E 1,555,000

N 287,000

425

430

425

425

425

400

5

Plate 58

MCAL-06B

FLOW
FLOW
FLOW

FLOW

EXISTING LOCK

EL 443

NEW LOCK

425

430

425

425

425

0 MINUTES

6 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400 300 200 100   0   400
MODEL   5   4   3   2   1   0   5

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 59

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON RIVERSIDE WALL NEAR LOCK
PLAN A – SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 60

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 61

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON LANDSIDE WALL NEAR LOCK
PLAN A – SCHEME 2

DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

14 MINUTES

1 MINUTE TIME STEPS

SCALES IN FEET

PROTOTYPE 400 300 200 100 0 400

MODEL 5 4 3 2 1 0 5

E 1,555,000

N 287,000

425

430

425

425

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MCAL-079

Plate 62

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 2
DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

Plate 63

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON RIVERSIDE WALL NEAR LOCK
PLAN A – SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 64

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 2

DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

13 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

430

425

425

425

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 400 300 200 100 0   400

MODEL 5 4 3 2 1 0   5

MCAL-082

Plate 65

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON LANDSIDE WALL NEAR LOCK
PLAN A - SCHEME 2
DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

Plate 66

MCAL-085

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON LANDSIDE WALL NEAR MID-POINT
PLAN A -SCHEME 2
DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

EXISTING LOCK
EL 443
NEW LOCK

FLOW
FLOW
FLOW
FLOW

0 MINUTES
1 MINUTE TIME STEPS
9 MINUTES

E 1,555,000
N 287,000

425
430
425
425

LEGEND
SMALL BOAT
NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET
PROTOTYPE   400   300   200   100   0   400
MODEL   5   4   3   2   1   0   5

Plate 67

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON RIVERSIDE WALL NEAR LOCK
PLAN A - SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 68

MCAL-088

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

FLOW

FLOW

425

430

424.5

425

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 2

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400

MODEL   5   4   3   2   1   0   5

Plate 69

ELEVATION IN FEET NGVD

385.0 — 385.0
384.0 — 384.0
383.0 — 383.0

STATION 1

385.0 — 385.0
384.0 — 384.0
383.0 — 383.0

STATION 2

385.0 — 385.0
384.0 — 384.0
383.0 — 383.0

STATION 3

385.0 — 385.0
384.0 — 384.0

STATION 4

0   5   10   15   20   25   30

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK   EXISTING LOCK

0   10   0   10

TIME IN MINUTES

WATER-SURFACE SURGES
NEW LOCK EMPTYING
PLAN A - SCHEME 3

RIVER DISCHARGE: 12,000   CFS
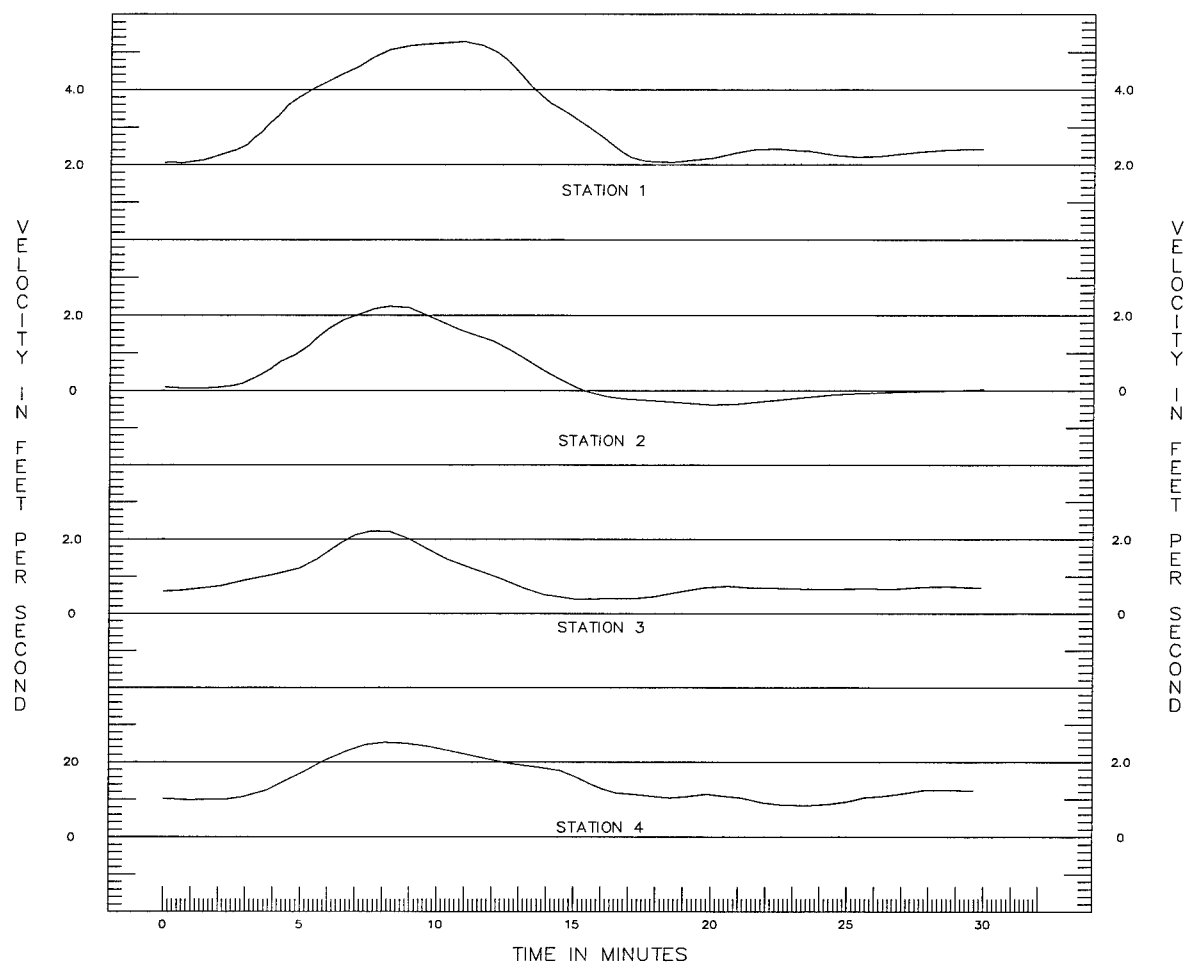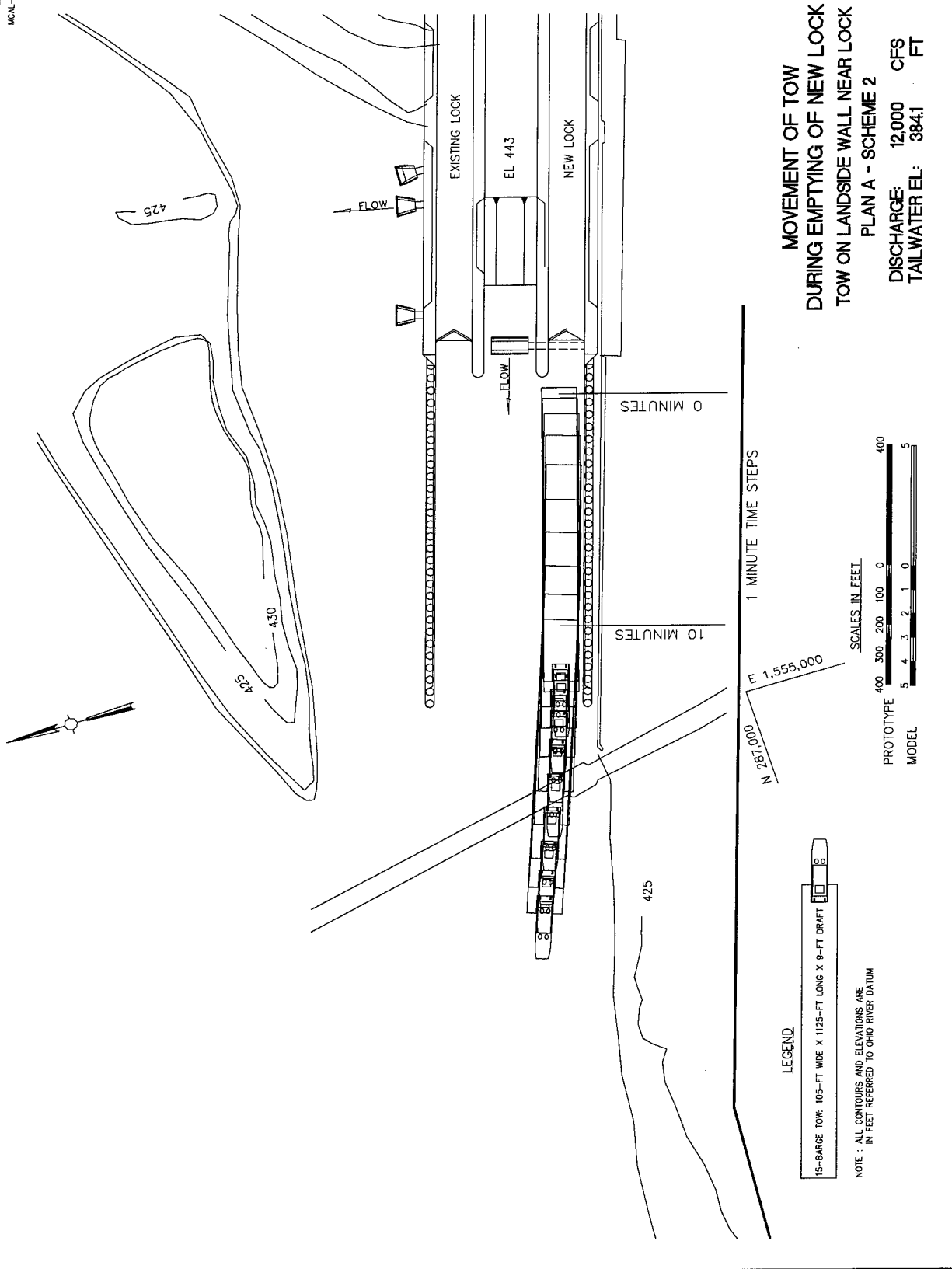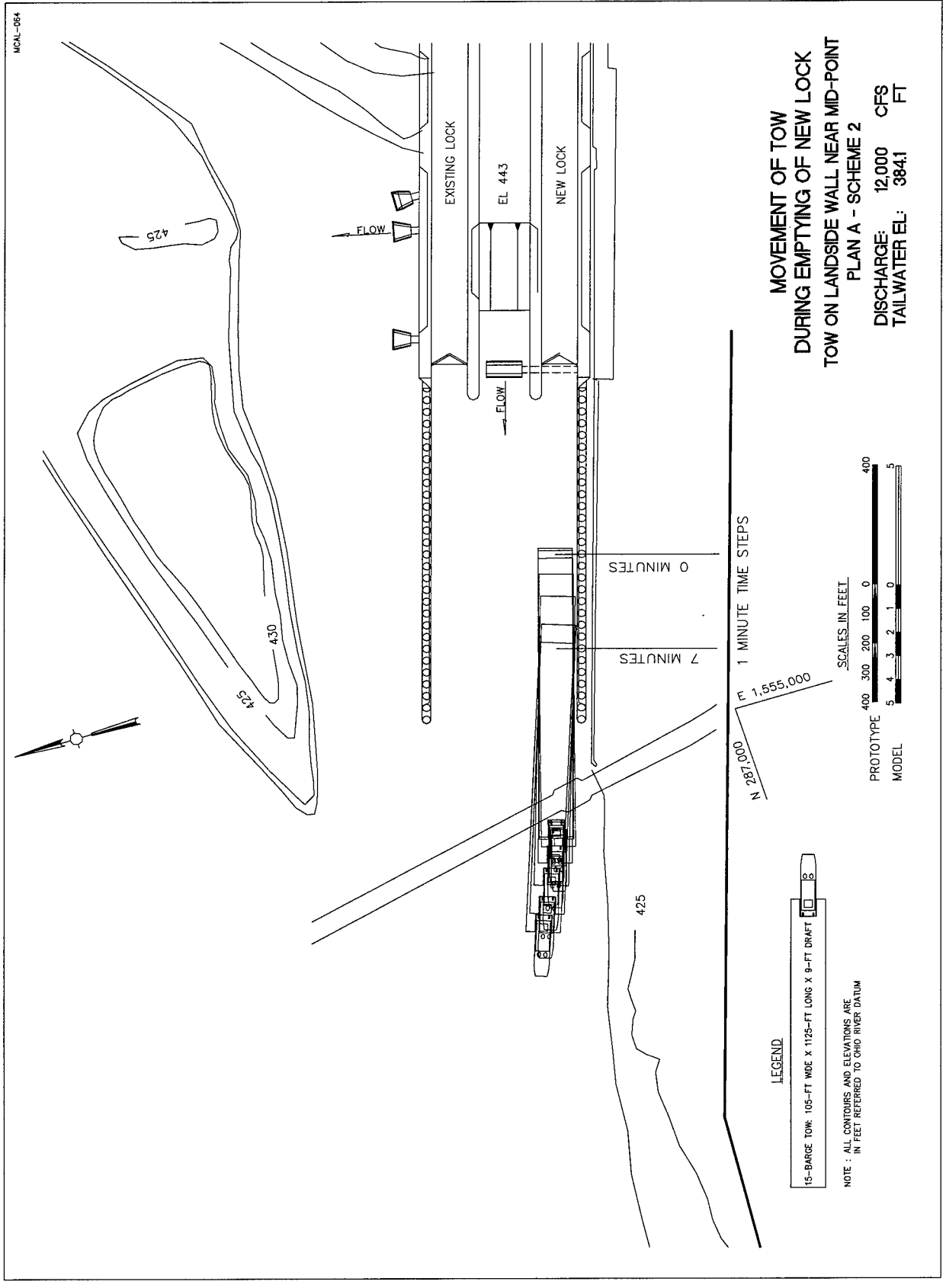UPPER POOL EL: 420.6   FT
LOWER POOL EL: 384.1   FT

Plate 70

STATION 1

STATION 2

STATION 3

STATION 4

VELOCITY IN FEET PER SECOND

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
NEW LOCK EMPTYING
PLAN A – SCHEME 3

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 71

MCAL—107

ELEVATION IN FEET NGVD

385.0 / 384.0 / 383.0 — STATION 1

385.0 / 384.0 / 383.0 — STATION 2

385.0 / 384.0 / 383.0 — STATION 3

385.0 / 384.0 — STATION 4

TIME IN MINUTES

0 5 10 15 20 25 30

ELEVATION IN FEET NGVD

420.0 / 415.0 / 410.0 / 405.0 / 400.0 / 395.0 / 390.0 / 385.0

NEW LOCK   EXISTING LOCK

TIME IN MINUTES

0 10 0 10

WATER-SURFACE SURGES
BOTH LOCKS EMPTYING
PLAN A - SCHEME 3

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 72

STATION 1

STATION 2

STATION 3

STATION 4

VELOCITY IN FEET PER SECOND

VELOCITY IN FEET PER SECOND

4.0
2.0

2.0
0

2.0
0

20
0

4.0
2.0

2.0
0

2.0
0

2.0
0

0   5   10   15   20   25   30

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK

EXISTING LOCK

0   10   0   10

TIME IN MINUTES

VELOCITY SURGES

BOTH LOCKS EMPTYING

PLAN A – SCHEME 3

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 73

MCAL-070

EXISTING LOCK

EL 443

NEW LOCK

FLOW
FLOW

425

430

425

425

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

SCALES IN FEET

PROTOTYPE   400 300 200 100 0   400

MODEL   5   4   3   2   1   0   5

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
        IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A – SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 74

MCAL-072

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

425

430

425

0 MINUTES

11 MINUTES

1 MINUTE TIME STEPS

N 287,000

E 1,555,000

425

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

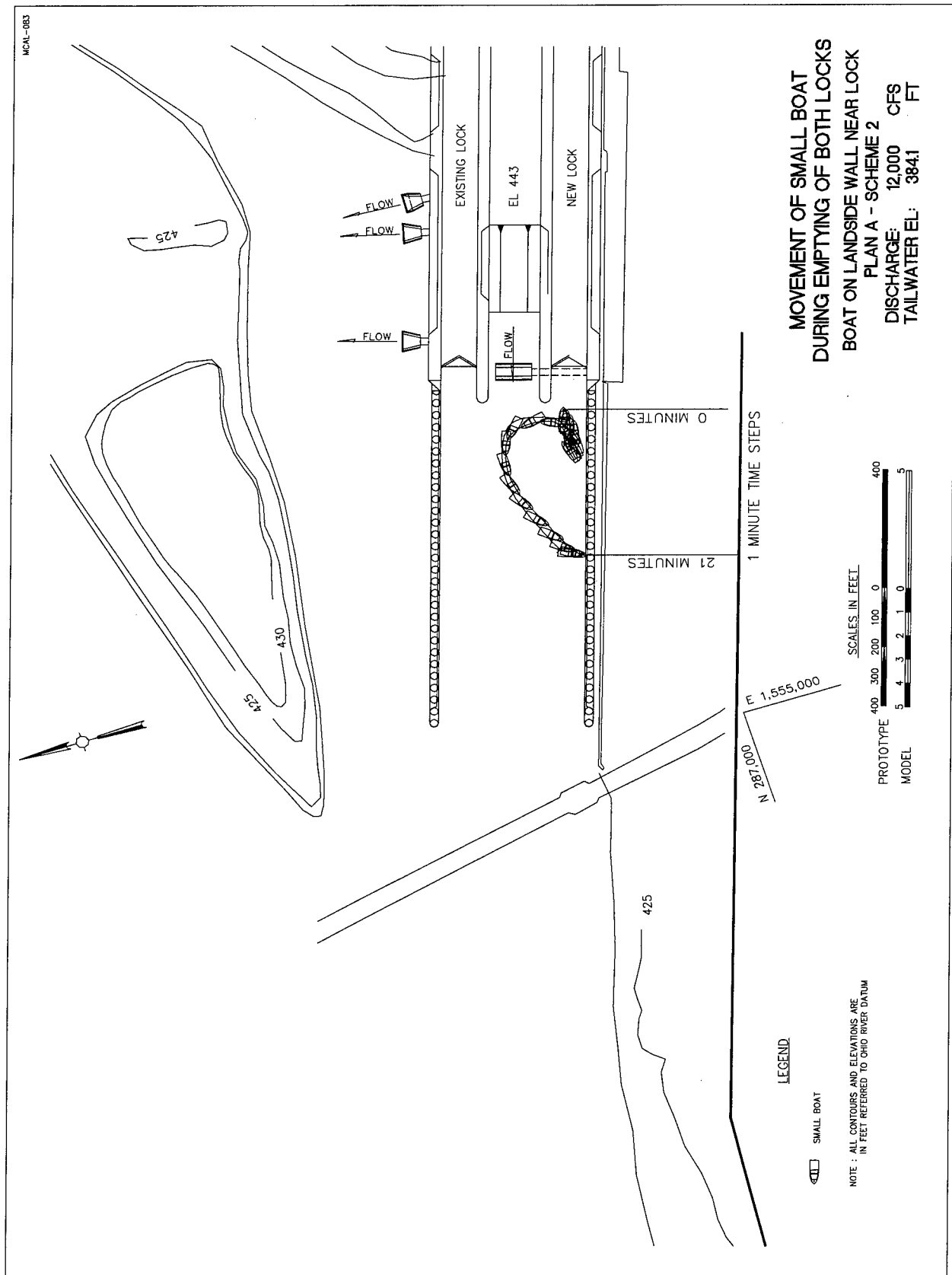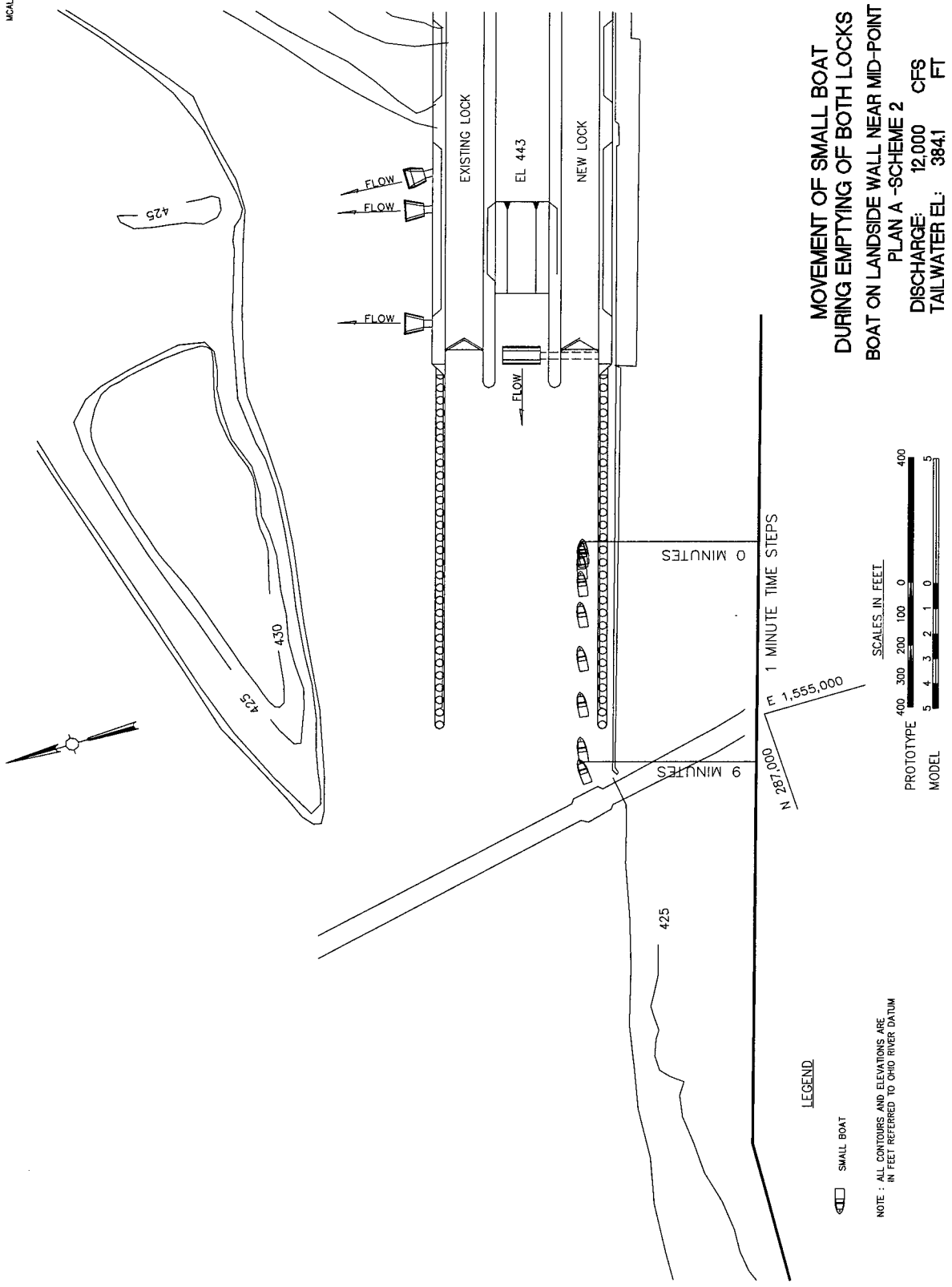NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK

TOW ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT
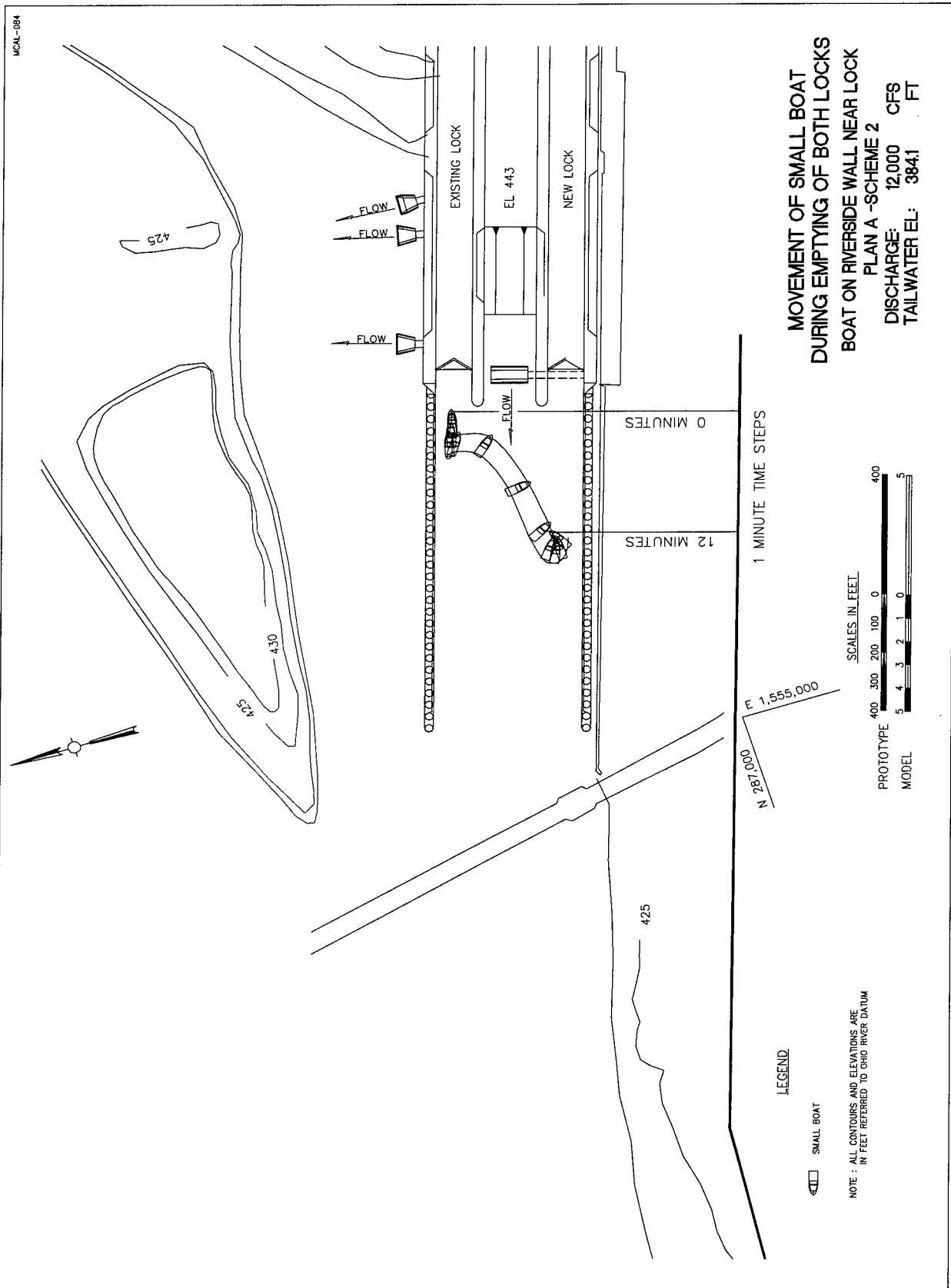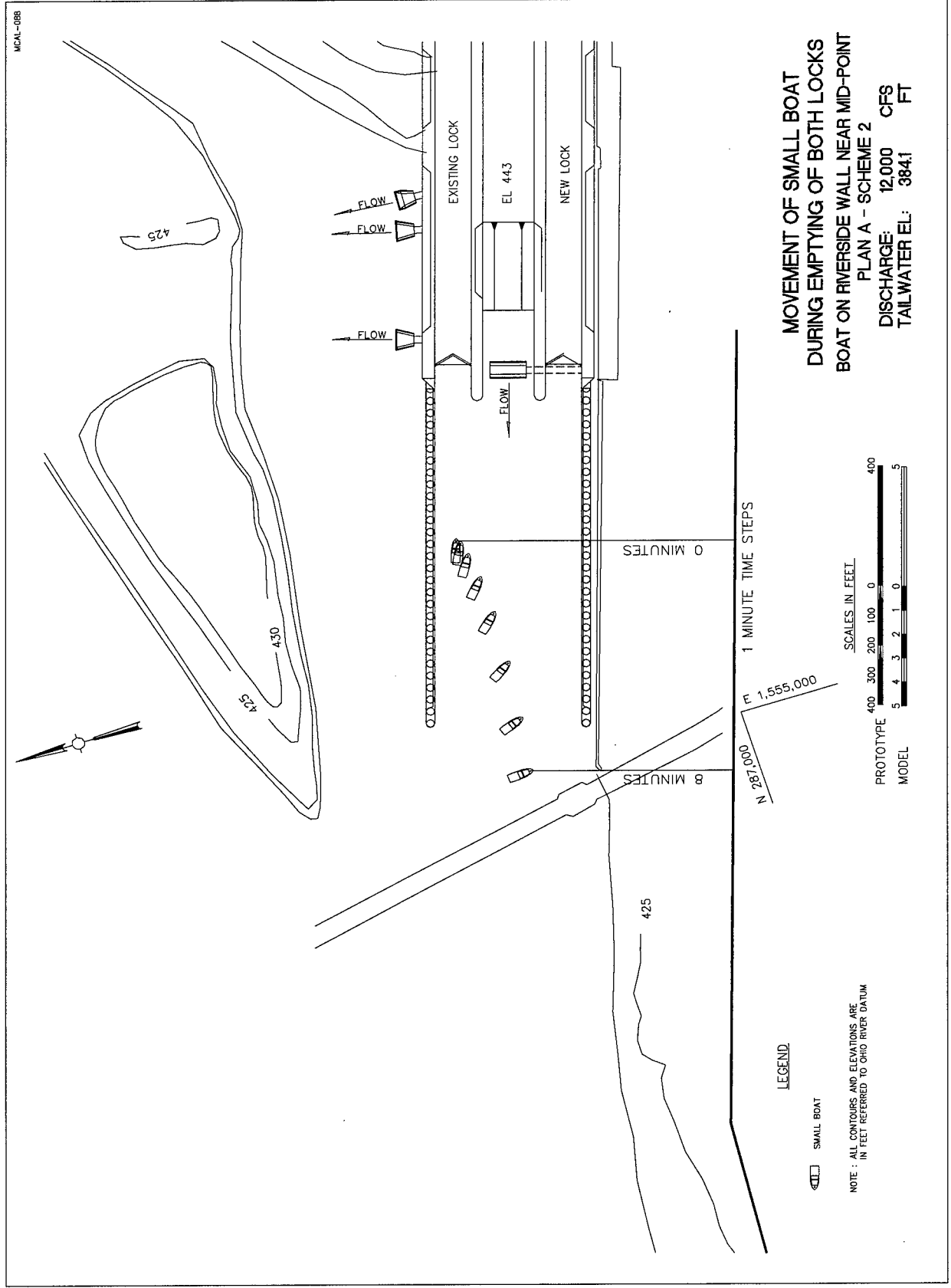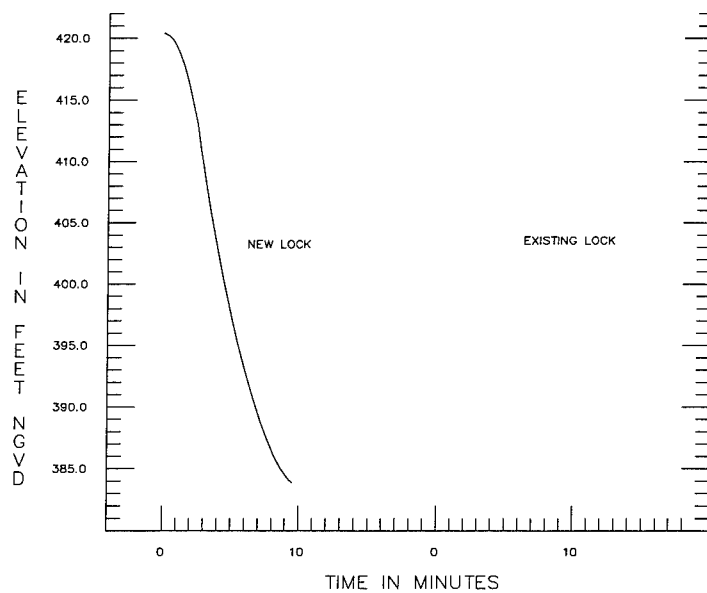
SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400

MODEL   5   4   3   2   1   0   5

Plate 75

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON RIVERSIDE WALL NEAR NEW LOCK
PLAN A – SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

LEGEND

15–BARGE TOW: 105–FT WIDE X 1125–FT LONG X 9–FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400 300 200 100 0   400
MODEL   5   4   3   2   1   0   5

1 MINUTE TIME STEPS

0 MINUTES

10 MINUTES

E 1,555,000

N 287,000

EXISTING LOCK

EL 443

NEW LOCK

FLOW

425

430

425

425

MCAL–71A

Plate 76

MCAL-073

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

425

430

425

425

0 MINUTES

10 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400

MODEL   5   4   3   2   1   0   5

MOVEMENT OF TOW
DURING EMPTYING OF NEW LOCK
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 3
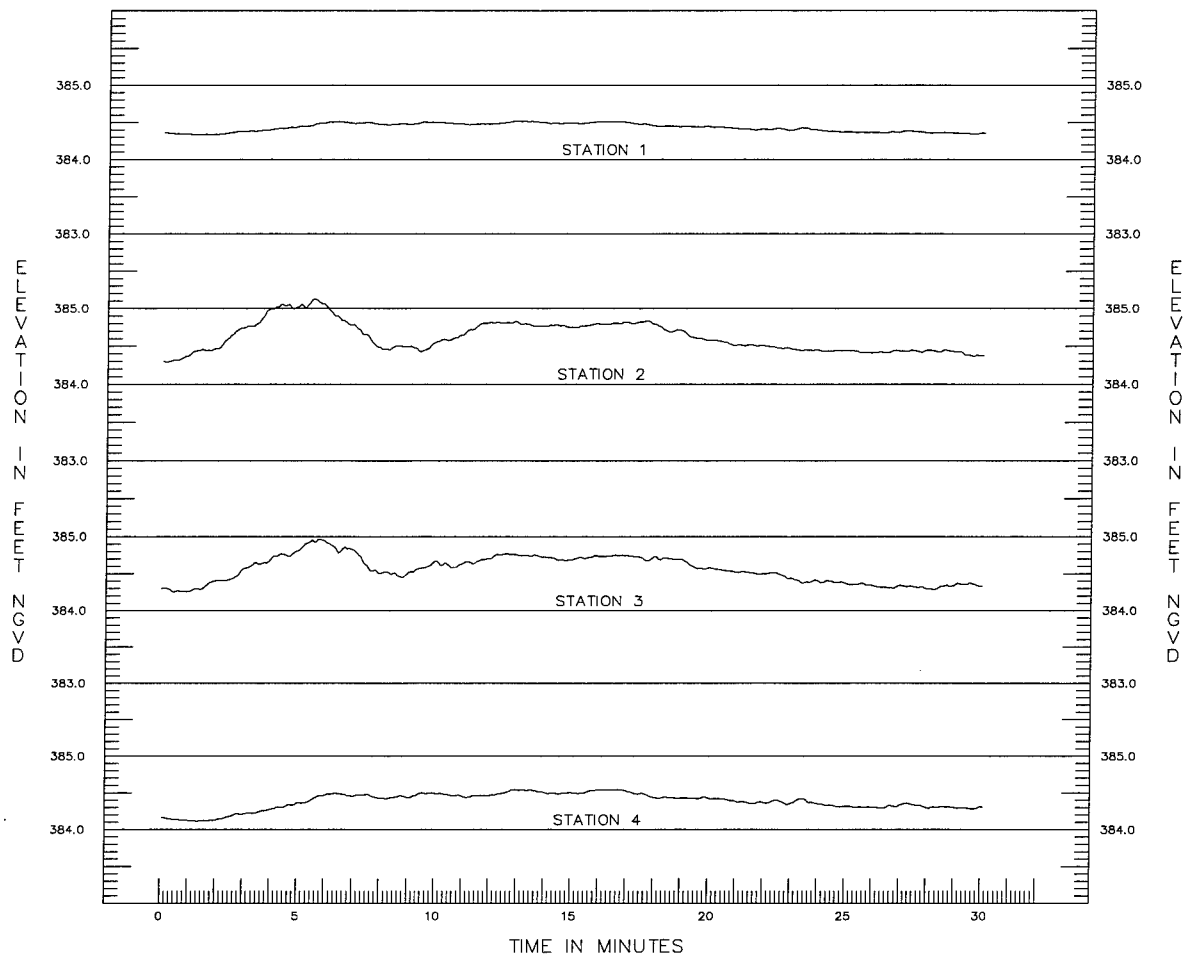
DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 77

MCAL-074

FLOW

425

430

425

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

FLOW

FLOW

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

N 287,000

E 1,555,000

425

SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400

MODEL   5   4   3   2   1   0   5

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON LANDSIDE WALL NEAR LOCK
PLAN A -SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 78

MCAL-076

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

FLOW

FLOW

FLOW

425

430

425

425

0 MINUTES

7 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400

MODEL   5   4   3   2   1   0   5

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON LANDSIDE WALL NEAR MID-POINT
PLAN A –SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 79

MCAL-075

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON RIVERSIDE WALL NEAR LOCK
PLAN A -SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW
FLOW
FLOW

FLOW
FLOW

0 MINUTES

1 MINUTE TIME STEPS

10 MINUTES

E 1,555,000

N 287,000

425

430

425

425

SCALES IN FEET

PROTOTYPE   400   300   200   100   0   400

MODEL   5   4   3   2   1   0   5

LEGEND

15-BARGE TOW: 105-FT WIDE X 1125-FT LONG X 9-FT DRAFT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

Plate 80

MOVEMENT OF TOW
DURING EMPTYING OF BOTH LOCKS
TOW ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 3

| DISCHARGE: | 12,000 | CFS |
| TAILWATER EL: | 384.1 | FT |

Plate 81

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON LANDSIDE WALL NEAR LOCK
PLAN A – SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 82

MCAL-091

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

425

430

425

425

425

N 287,000

E 1,555,000

0 MINUTES

11 MINUTES

1 MINUTE TIME STEPS

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 3

| DISCHARGE: | 12,000 | CFS |
| TAILWATER EL: | 384.1 | FT |

SCALES IN FEET

PROTOTYPE   400 300 200 100 0   400

MODEL   5   4   3   2   1   0   5

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

Plate 83

MCAL-090

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON RIVERSIDE WALL NEAR LOCK
PLAN A -SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

15 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

430

425

425

425

SCALES IN FEET

PROTOTYPE   400 300 200 100   0   400

MODEL   5   4   3   2   1   0   5

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
       IN FEET REFERRED TO OHIO RIVER DATUM

Plate 84

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF NEW LOCK
BOAT ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 3
DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

EXISTING LOCK

EL 443

NEW LOCK

FLOW

FLOW

0 MINUTES

17 MINUTES

1 MINUTE TIME STEPS

425

430

425

425

425

E 1,555,000

N 287,000

SCALES IN FEET

PROTOTYPE 400 300 200 100 0 400

MODEL 5 4 3 2 1 0 5

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

MCAL-092

Plate 85

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS

BOAT ON LANDSIDE WALL NEAR LOCK
PLAN A – SCHEME 3
DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

Plate 86

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON LANDSIDE WALL NEAR MID-POINT
PLAN A - SCHEME 3
DISCHARGE: 12,000 CFS
TAILWATER EL: 384.1 FT

Plate 87

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON RIVERSIDE WALL NEAR LOCK
PLAN A - SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 88

MCAL-096

EXISTING LOCK

FLOW

FLOW

425

430

425

EL 443

NEW LOCK

FLOW

FLOW

FLOW

0 MINUTES

8 MINUTES

1 MINUTE TIME STEPS

E 1,555,000

N 287,000

425

LEGEND

SMALL BOAT

NOTE : ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE   400 300 200 100   0   400

MODEL   5   4   3   2   1   0   5

MOVEMENT OF SMALL BOAT
DURING EMPTYING OF BOTH LOCKS
BOAT ON RIVERSIDE WALL NEAR MID-POINT
PLAN A – SCHEME 3

DISCHARGE: 12,000   CFS
TAILWATER EL: 384.1   FT

Plate 89

ELEVATION IN FEET NGVD

STATION 1

STATION 2

STATION 3

STATION 4

STATION 5

TIME IN MINUTES

NEW LOCK

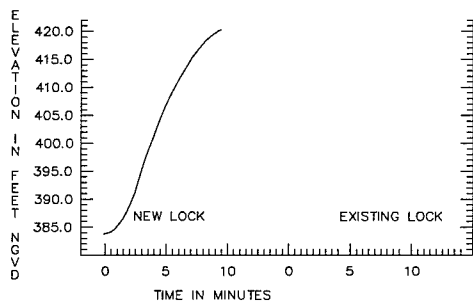EXISTING LOCK

ELEVATION IN FEET NGVD
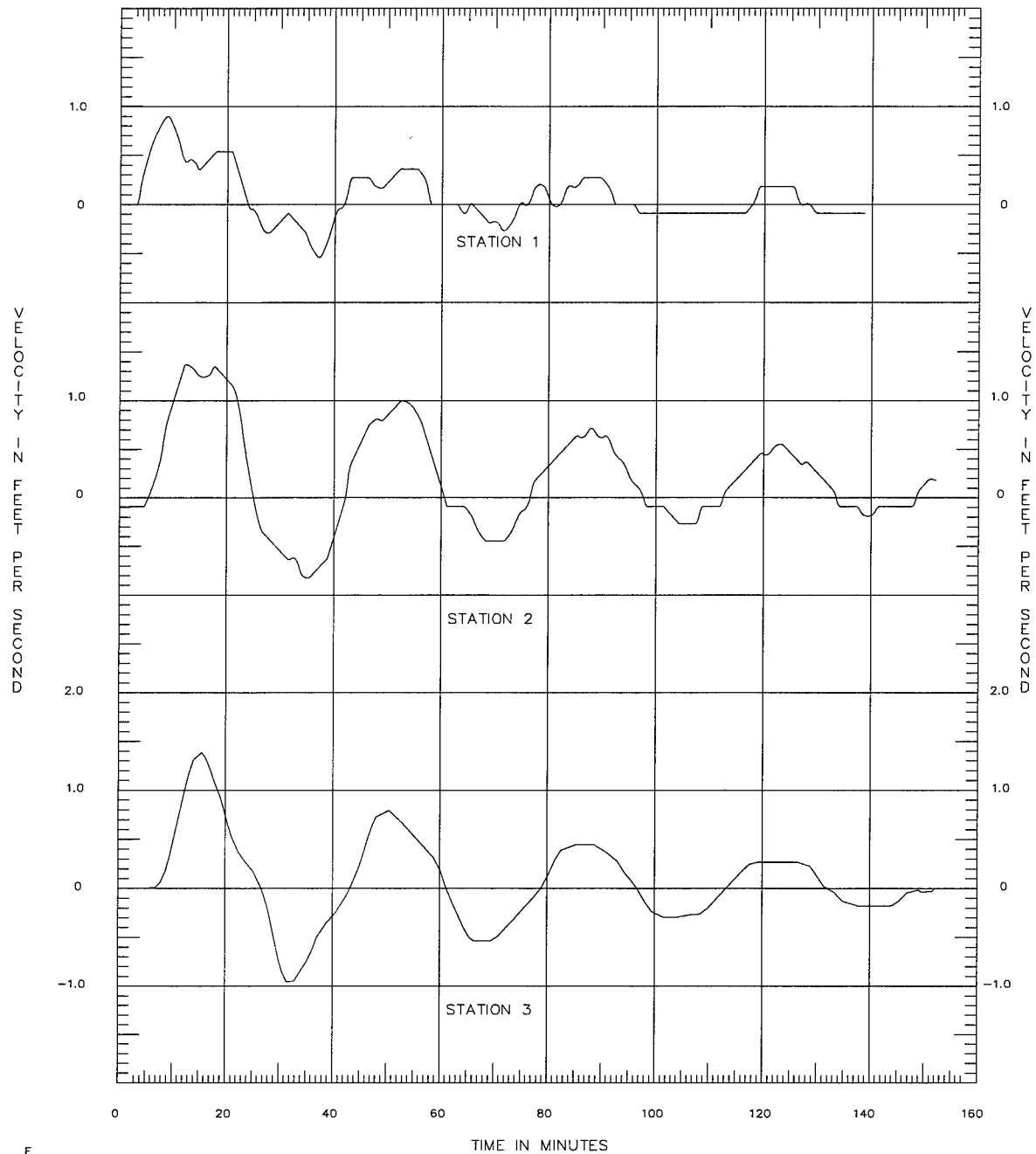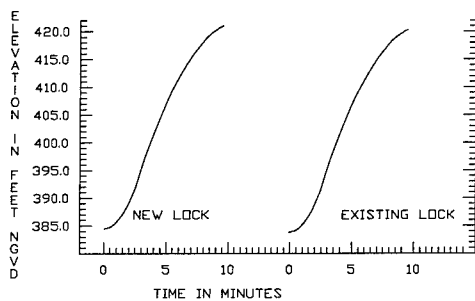
TIME IN MINUTES

WATER-SURFACE SURGES
NEW LOCK FILLING
PLAN B

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 90

MCAL-139

VELOCITY IN FEET PER SECOND

STATION 1

STATION 2

STATION 3

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK   EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES

NEW LOCK FILLING

PLAN B

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL.:	420.6	FT
LOWER POOL EL.:	384.1	FT

Plate 91

ELEVATION IN FEET NGVD

STATION 1

STATION 2

STATION 3

STATION 4

STATION 5

TIME IN MINUTES

ELEVATION IN FEET NGVD

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

WATER-SURFACE SURGES
BOTH LOCKS FILLING
PLAN B

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 92

VELOCITY IN FEET PER SECOND

STATION 1

STATION 2

STATION 3

TIME IN MINUTES

ELEVATION IN FEET NGVD

420.0
415.0
410.0
405.0
400.0
395.0
390.0
385.0

NEW LOCK

EXISTING LOCK

TIME IN MINUTES

VELOCITY SURGES
BOTH LOCKS FILLING
PLAN B

RIVER DISCHARGE:	12,000	CFS
UPPER POOL EL:	420.6	FT
LOWER POOL EL:	384.1	FT

Plate 93

REPORT DOCUMENTATION PAGE

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13.ABSTRACT *(Maximum 200 words)*

McAlpine Locks and Dam are on the Ohio River at the northwestern end of Louisville, KY, 606.8 miles below Pittsburgh, PA. The structures, including the dam, the canal, and locks, extend from mile 604.4 to mile 607.4. The upper pool of the dam extends approximately 75 miles upstream to Markland Locks and Dam near Warsaw, KY.

The provisional plan recommended in the McAlpine Navigation Feasibility Report consists of constructing an additional 110- by 1,200-ft lock in place of the existing auxiliary chamber. This would result in two locks 110 ft wide by 1,200 ft long. The new lock would be parallel to the existing 1,200-ft lock, with the upper gates in approximately the same location as the existing lock upper gate. A guide wall would extend upstream 1,275 ft beyond the upper miter gate monolith and tie into the existing canal wall. A south guide wall would extend 1,200 ft beyond the lower miter gate monolith.

A fixed-bed model reproduced the Louisville and Portland Canal, the existing locks, a limited section of the Ohio River immediately upstream of the canal, that part of the river channel between Shippingport Island and the fixed crest weir connecting the upper and lower spillways, and the lower approach to the locks at an undistorted scale of 1:80. Upstream of the lower spillway, the right descending model limits followed the alignment of the fixed crest weir from the upper gated

(Continued)

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spillway to the lower gated spillway. However, as the model would not be reproducing any riverflows that would create flow over the fixed crest weir, the crest elevation of the weir was not reproduced in the model.

The general design of the new 1,200-ft-long lock was complicated by its proximity to the existing 1,200-ft lock, its placement at the downstream end of a long approach canal, and the restricted area downstream of the lock available for lock discharge laterals. Because of the many design factors that had to be considered, a physical model was considered necessary to evaluate navigation conditions in both the upper and lower approaches to the locks. Surges created by filling the existing 1,200-ft lock had the potential to cause adverse navigation conditions in the Louisville and Portland Canal. Filling two 1,200-ft locks from the canal could create a more serious problem in the future. The comprehensive model study was necessary to (a) evaluate the effect of surges on tows near the locks; (b) develop guidance for future project operations to reduce or eliminate problems associated with lock filling; (c) evaluate bendway widening near the locks; (d) evaluate necessary clearances between tows and resolve other questions relating to multiple tow movements in the canal; and (e) investigate the impact of lock emptying on navigation in the lower approaches to the locks.